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Geodynamic Reinterpretation Model for Ptolemy's *Germania Magna*

General Model Description, Cartometric Foundations, Extended Evidence Analysis, and Impact Hypothesis

Version 7 – Unified Abnobae Mons hypothesis; Rhenus/Danubius source identification; revised trigger budget; three-scenario impactor analysis; mathematical- overdetermination defence; Vistula=Lausitz cross-check; extended Elster cluster ($n = 6$, t=−19.1)

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Builds upon and extends:

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Related resources: https://www.ancientmaps-geography.com | https://www.germania-magna.de

Principal substantive revisions in Version 7 (all v1–v6 content retained)

The following revisions extend v6, building on its kinematic taxonomy, latitude bias system, Waltershausen pivot, and biaxial corridor framework. All earlier statements not geometrically or physically falsified are preserved.

1. **Methodological repositioning:** The manuscript is reorganised around a methods-paper-style abstract foregrounding the kinematic block-deformation framework and the statistically significant RMSE reduction. The impact scenario is presented as a theoretically consistent geodynamic driver to be tested by OSL, AFT, SHRIMP, RSCM, and reflection-seismic profiling.
2. **Unified Abnobae Mons hypothesis (new Part V):** The Ptolemaic *Abnoba Mons* is reinterpreted as a single coherent crustal block encompassing the modern Taunus, Odenwald, Spessart, Rhön, and the pre-Vogelsberg basement. Fragmentation into separate ranges is the post-deformation result of a $\sim -22°$ sinistral rotation of the southern portion about the Waltershausen universal pivot, with the Vogelsberg/Wetterau zone interpreted as a pull-apart filling.
3. **Rhenus/Danubius source identification:** Pre-deformation positions by inverse rotation: Rhenus source at ∼8.60°E / 50.06°N (modern Amorbach, displacement ∼63 km ESE); Danubius source at ∼8.96°E / 50.07°N (modern Marktheidenfeld/Wertheim, displacement ∼55 km ESE). Pre-deformation inter-source distance only ∼26 km — consistent with Mercator's 1569 cartographic representation.
4. **Revised trigger budget (§14):** Africa/CDF contribution reduced from 40 % to ∼10 %; SU raised from 20 % to 50 %; CK raised from 25 % to 35 %; Bramsche reduced from 15 % to 5 %. Justified by direct down-range coupling of the SU ejecta lobe with the Elster Cluster pre-shift positions.
5. **Three-scenario impactor-size analysis (§48):** Scenario A′ (multi-fragment, main scenario); Scenario B (single 500 m–1 km dominant impactor); Scenario C (2–5 km, upper bound). All three bracketed within model uncertainty.
6. **Vistula proportional cross-check (§6.4):** Ptolemy's internal Harz–Vistula proportions predict a distance of ≈325 km; the Mildner/Oder model gives ≈300 km (close match) whereas the Lelgemann/Polish-Vistula identification gives ≈620 km (irreconcilable by factor 2). *Decisive cartometric evidence for the Vistula = Lausitz identification.*
7. **Extended Elster Cluster ($n = 6$):** Three new Ptolemaic identifications — Leukaristos (Finsterwalde, $\Delta\lambda = -87.4$ km); Arsonion (Senftenberg zone, $\Delta\lambda = -51.5$ km, Décollement transition zone); Carrodunum (Spreetal/Nochten, $\Delta\lambda = -85.0$ km) — improve the t-test from $t = -13.7$, $df = 3$ to $t = -19.1$, $df = 5$.

8. **Doberlug-Kirchhain pressure-cooker mechanism (§31):** Steep 40°–60° dips, fragmented seam blocks, and discordant Zechstein cover explained by forced crustal wedging into the Fläming–Lausitz vise; frictional heating sealed under evaporite cap.
9. **Coal corridor SU ↔ CK (§32):** Doberlug-Kirchhain anthracite, Saxon hard coal (Döhlen, Lugau-Oelsnitz), and Lower Saxon coals interpreted as a spatially coherent shock/ground-wave coalification corridor.
10. **Erzgebirge ore interference grid (§17.6):** NE-SW Variscan fabric intersects the NW-SE biaxial corridor; ore deposits concentrate at intersection nodes.
11. **Cimbrian Peninsula clarification (§6.3):** Ancient Cimbri promontory = Lüneburg Heath extending to the Mecklenburg Bay margin; not modern Jutland.
12. **Vistula western source at Ottendorf-Okrilla (§24.3):** F2 revised from Königsbrück/Pulsnitz to Ottendorf-Okrilla (13.819°E / 51.201°N); bias-corrected residual $r_{\mathrm{corr}} = 127.2\,\mathrm{km}$. Paläogeographically justified by the *Senftenberger Elbelauf* (Miozän, documented in gravel-mining exposures) and the artesian Cenomanian–Sandstone aquifer (Albertplatz analogue, Dresden-Neustadt, 17.8°C).
13. **Mathematical-overdetermination defence (§55):** Explicit treatment of $F < 0$ (overdetermined) system; seven independent simultaneous constraints; statistical refutation of the measurement-error null model.
14. **Three methodological objections addressed (§56); Falsification tests T1–T34 (T12–T34 are new in v7)**

Keywords: Ptolemy, *Germania Magna*, cartometric residual minimisation, kinematic block-deformation modelling, Abnobae Mons unified-block hypothesis, Waltershausen universal pivot, Rhenus / Danubius source identification, Vogelsberg pull-apart, Doberlug-Kirchhain pressure-cooker, Fläming guide-rail, Lausitz buttress, Vistula = Lausitz, Cimbrian peninsula, Erzgebirge interference grid, Saale-Unstrut Fragment Impact, Český Kráter, biaxial corridor, mathematical overdetermination, Event-Dark-Earth, 536 AD crisis.

Disclaimer and scope

This manuscript presents an interdisciplinary working hypothesis integrating cartometry, geodynamics, sedimentology, impact mechanics, and historical sources. It formulates concrete, falsifiable predictions and is intended to stimulate further empirical testing. It does not claim to constitute a definitive reconstruction, and has not been evaluated by peer review. The Saale-Unstrut Fragment Impact remains a *working hypothesis*; no impact structure in this region is currently recognised in the peer-reviewed impact-cratering literature. Where geological dating presently conflicts with the kinematic interpretation, the **primary commitment of v7 is to the geometric–kinematic mechanism**, with the explicit recognition that radiometric, palaeomagnetic, and stratigraphic chronologies provide the strongest empirical tests of the model and must be allowed to falsify it.

Contents

1 Abstract (methods-paper framing, primary) 8

2 Abstract (classical descriptive, supplementary) 9

3 Introduction: Scope, Method, and Positioning 9

I General Model Description: Foundations, Mechanisms, and Interdisciplinary Framework 10

4 The Event-Dark-Earth (ED-E) as Catastrophic Sediment Archive 10

4.1 Critique of the Gardening Theory 11
4.2 The Gaberz Database and its Reinterpretation 11
4.3 Falsifiable Predictions for the ED-E Horizon 11
4.4 Palynology as Ecological Protocol 12

5 Reinterpretation of the 6th-Century Historical and Archaeological Record 12

5.1 The Collapse of the Thuringian Kingdom 12
5.2 Scandia: An Island Massif in Mecklenburg-Western Pomerania 12

6 Cartometric Reinterpretation of Ptolemy's Map and Key Geographical Reidentifications 12

6.1 The Affine Transformation and the Global Scaling Factor 12
6.2 Key Geographical Reidentifications 14
6.3 The Cimbrian Peninsula Reconsidered (new in v7) 14
6.4 Vistula=Lausitz: Proportional Cross-Check 15
6.5 The Elster Cluster: Budorigum, Limis Lucus, Lugidunum, Stragona (updated in v7) 15

7 The Danubius Fluvius as Southern Validation Anchor: Latitude Bias Parameter and Source-Position Resolution 16

7.1 The Southern Calibration Gap in Earlier Versions 16
7.2 V7 update: source-position resolution 16
7.3 Formalisation of the Latitude Bias Gradient 16
7.4 Adoption of c = 15.2 km/degree as Main Scenario 17
7.5 G8 Promoted to K4: Taunus as Fourth Calibration Reference 17
7.6 Geometric Verification: Sudete Rotation via Danubius Proximity . . . 17
7.7 The Pre-Deformation Parallelism of Sudete Mons and Danubius 18

7.8 The Anduaetium / Bamberg Hypothesis as Secondary Danubius Anchor 18

8 Kinematic Classification of the Deformed Blocks: Translation-Glide vs. Rigid Rotation 20
8.1 Diagnostic Test: Pivot–Distance Conservation 20
8.2 The Elster-Cluster: A Translation-Glide Block with SSE Component . 20
8.2.1 The SSE Component of the Elster Translation 20
8.2.2 Extended Cluster: Leukaristos, Arsonion, Carrodunum (new in v7) 22
8.2.3 Coulomb-Wedge Gradient: Physical Interpretation of Arsonion . 22
8.3 The Sudete-Mons Block: Rigid Rotation with Revised Pivot 23
8.4 Summary of the Kinematic Taxonomy 24
8.5 G7 (Sarmate Mons N): Biaxial Lateral Extrusion 24
8.6 V7 Unified Extension: Counter-Rotation of Southern Abnobae about the Same Waltershausen Pivot 25
8.7 Summary of the Kinematic Taxonomy (v7-updated) 26

9 Multi-Layer Kinematics: the Zechstein-Décollement Hypothesis 27

10 Cometary Signatures and Impact Structures: The Český Kráter 27

11 The Saale-Unstrut Fragment Impact: Crater Geometry and Primary Local Driver 27
11.1 V7 Update: SU as Primary Elster-Translation Driver (Revised Attribution) 27

12 The Geometry of the Sudete Rotation: Pivot and Lever-Arm Computation 28
12.1 V7 Unification Statement 28
12.2 Pivot and Lever-Arm Geometry 28
12.3 Northward and Southward Terminus Displacement as a Function of Rotation Angle 29
12.3.1 The Rotation Pivot as Central Block Hinge: Waltershausen . . 30
12.3.2 NW-Flank Dual Geometric Alignment 33
12.4 G7 (Sarmate Mons N): Biaxial Lateral Extrusion 33
12.5 The Thüringer Wald as a Centrally Pivoted Rotation Structure 34

13 Three Parallel Force Vectors and the Geodynamic Chain Reaction 34
13.1 Vector A: CDF Reactivation and the Africa Impactor Hypothesis . . . 34
13.2 Vector B: Český Kráter Impact — SE-Compression and Westward Compression 35

13.3 Vector C: Saale-Unstrut Fragment Impact — Primary Local Driver of the Sudete Rotation 36
13.4 Vector D: Bramsche Pluton — Passive Structural Endpoint 36

14 Quantitative Trigger Budget (revised v7) 37

15 Main-Valley Buckling: Geometric Corollary of the Český-Kráter Shock Wave 37
15.1 Geometric Coincidence with the Force Field 38
15.2 Mechanical Interpretation 38
15.3 V7 Update: Timing Relative to the Unified Abnobae Rotation 39

16 Impact-Triggered Fracturing, Secondary Volcanism, and Hydrothermal Activity 40
16.1 Permian Volcanic-Hydrothermal Precursor 40
16.2 Tertiary Reworking and Economic Deposits 40
16.3 Shock Minerals as Structural Tracers 41

17 The Geodynamic Chain-Reaction Model 41
17.1 Lithospheric Weaknesses and Tectonic Reactivation 41
17.2 The North Sea Central Graben as Compressional Syncline 41
17.3 The Biaxial Bramsche–Český Kráter Stress Field 42
17.4 The Lausitz Block as Rigid Backstop 42
17.5 The Storegga Slide and Doggerland 42
17.6 V7 Update: Erzgebirge Ore Deposits as an Interference Grid (new) . . 43
17.7 Methodological Robustness: Against Rubber-Sheeting 43

18 Summary of Part I: Conclusions 44

II Cartometric Foundations, Residual Analysis, Statistical Interpretation, and Bias-Corrected System 46

19 Introduction to the Cartometric Model 46

20 The Cartometric Transformation Model 46
20.1 Scaling of the Ptolemaic Degree of Longitude 46

21 Residual Analysis of the Gazetteer (v7-updated) 47
21.1 Methodology 47

22 Latitude Bias System and Bias-Corrected Residuals 49

22.1 The Two-Point Constraint System 49

23 Statistical Evaluation and Group Analysis (v7-updated) 50
23.1 Regional RMSE Analysis (v7) 50
23.2 Extended t-Test: Elster Cluster (n=6) 51

24 Geodynamic Interpretation of the Residual Patterns 52
24.1 The Elster-Cluster Translation-Glide (Reformulated in v5) 52
24.2 Geochemical Verification: Anthracite at Budorigum 52
24.3 Ottendorf-Okrilla Artesian System: Physical Anchor for F2 53

25 Methodological Defence against Criticism (v7: seven constraints) 53

26 Summary of Part II: Conclusions 54

III Extended Evidence Analysis: CDF Reactivation, Radial Kaolin Genesis, Anthracite Overprinting, and Tsunami-Driven Coastal Migration 55

27 Synthesis of Evidence Chains: The Necessity of an Integrated View 55

28 The Reactivatability of the CDF: Plate Stress Transmission 55
28.1 Core Finding of the Study 55
28.2 Relevance for CDF Reactivation 56

29 Anomalous Quaternary Subsidence: Arfai et al. (2018) 56
29.1 Data Findings 56
29.2 Reinterpretation 57

30 Radial Kaolin Genesis Around the Český Kráter 57
30.1 Götze et al. (2024): Magmatic-Hydrothermal Genesis in NW-Saxony . 57
30.2 Distance Analysis: Three-Zone Model 58
30.3 Binomial Distance Analysis 58
30.4 The Saale-Unstrut / Český Kráter Inter-Impact Corridor and Coal Deposits 59

31 The Doberlug-Kirchhain Anthracite Anomaly: v7 Pressure-Cooker Mechanism 59
31.1 Quantitative Kinematics 61
31.2 Quantitative Thermodynamics: the Pressure-Cooker 61

32 The Coal Corridor SU ↔ CK (new in v7) 62

33 The Storegga Slide, Doggerland, and the Mercator Map Argument 63
33.1 Data Situation: Weninger et al. (2008) 63
33.2 The *Albionis Pars* Argument 63

34 Tsunami Sediment as a Mechanism of Northward Coastal Migration 63

35 Prehistoric RSL Documentation and the Scandia Argument 64

36 Integrated Evidence Assessment 64

IV The Saale-Unstrut Fragment Impact Hypothesis: Crustal Stress Fields, Biaxial Extrusion, Three-Scenario Impactor Analysis, and Revised Plausibility Assessment 66

37 Introduction to the Impact Hypothesis (Part IV) 66

38 Pre-Displacement Geometry and Geology of the Crustal Gap Zone 66
38.1 Reconstructed Pre-Displacement Positions 66
38.2 Geology of the Crustal Gap Zone 67

39 Impact Mechanics: Shock Pressure and Transmission 68
39.1 Contact Pressure and Projectile Parameters 68
39.2 Pressures at Key Structural Targets 69
39.3 Fault-Guided Wave Amplification 69

40 G7 Biaxial Lateral Extrusion: Geometric Derivation 70
40.1 Observed Displacement Azimuth 70
40.2 Expected Biaxial Extrusion Azimuth 70
40.3 G7 Pre-Deformation Position on the Biaxial Axis 70
40.4 SU vs. CK Contribution to G7 Extrusion 71

41 The CDF: Multi-Fragment Activation 71

42 The Bramsche–Český Kráter Biaxial Stress Field 71

43 The Elbe Lineament as Primary Transmission Channel 71

44 Crustal Translation Kinematics: The −93 km Block Displacement (v6 formulation) 72

45 The Český Kráter at Tábor: Structure and Alpine-Carpathian Geodynamics 72

46 The Herzberg Earthquake of 18 October 2024: Spatial Correlation Analysis 72
46.1 Seismological Parameters 72
46.2 The Elliptical Deformation Model and Predicted Stress Maxima 73
46.3 Distance Between Predicted Focus and Observed Epicentre 73
46.4 Recurrence Interval and Stress-Relaxation Cycle 73

47 Historical and Mythological Corroboration 74
47.1 Convergence of Independent Evidence Chains 74
47.2 The Chronicle of Michael the Great of Syria 75
47.3 The Thuringian Kingdom, the Nibelungenlied, and the Kyffhäuser Legend 75

48 Three-Scenario Impactor-Size Analysis (new in v7) 76
48.1 The Rajlich Structure and Younger Age Interpretation 77
48.2 Structural Parameters 78
48.3 The Alpine-Carpathian Bow-Shock Morphology 78
48.4 Bavarian Dark Earth Horizons: Hydrodynamic Mechanisms 78

49 Integrated Plausibility Assessment (v7) 79

V The Unified Abnobae Mons Hypothesis: A New Constraint on the Universal Pivot and the Pre-Deformation Geography 82

50 The Unified Abnobae Mons: Geological Setting and Pre-Deformation Geometry 82
50.1 Motivation 82
50.2 Structural Identification 82
50.3 The Hunsrück–Taunus Boundary Fault (HTBF) as Active Separator . . 82
50.4 The Southern Boundary of the Mobile Block 83

51 The Waltershausen Universal Pivot: Quantitative Geometry 83
51.1 Lever-Arm Computation for the Southern Abnobae 83
51.2 Inverse Rotation of the Amorbach Point 83
51.3 The Danubius Source Identification 84
51.4 Pre-Deformation Inter-Source Distance 84
51.5 Mercator Cartographic Test 84

52 The Vogelsberg/Wetterau as Pull-Apart Filling 84
52.1 The Kinematic Role 84

52.2 The Two-Phase Rotation Interpretation 85
52.3 The Rhön as NE Peripheral Element 85

53 The River Capture: Mud/Mümling from proto-Rhenus to Main 86

54 Falsifiability of the Unified Abnobae Hypothesis 86

VI Methodological Defence 87

55 Mathematical Overdetermination as Methodological Core 87

56 The Three Principal Objections Addressed 87

57 Conclusions: Outlook 88

References 92

A Appendix A: Complete Coordinate Gazetteer (v7-updated) 95
A.1 Saale-Unstrut Crater Geometry 98
A.2 Tentative Anduaetium Identification (NEW in v6) 99
A.3 CDF and Elbe-Lineament Reference Points 100
A.4 Mineral Deposit Coordinates (from KML, unchanged from v4) 100

1. Abstract (methods-paper framing, primary)

The reconstruction of spatial coordinates from Claudius Ptolemy's *Geographike Hyphegesis* (c. 150 AD) for Central Europe has historically been hindered by significant and spatially autocorrelated residual errors. While the traditional cartographic consensus attributes these discrepancies primarily to cumulative human measurement errors or medieval copyist distortions, this paper introduces and successively refines an alternative, quantitative methodology based on *kinematic block-deformation modelling*. Using GIS-anchored affine transformations, a rigidly constrained multi-parameter framework ($k \approx 27.0\,\mathrm{km}/^{\circ}_{P}$) is established incorporating geometric scaling, hydrographic topological anchors, and structural block kinematics.

Rather than treating coordinate shifts as arbitrary map distortion, the model tests the mathematical coherence of treating the Elster-Lusatia geographic cluster as a *translation-glide block* relative to a rigid Lausitz backstop. With the Leukaristos (Finsterwalde), Arsonion (Senftenberg zone), and Carrodunum (Spreetal/Nochten) identifications added, the statistical test yields $t = -19.1$, $p \ll 0.001$, $df = 5$ — firmly ruling out uniform measurement error. The Arsonion identification localises the Décollement-abscherfront (Zechstein décollement tip), completing the kinematic picture of beginning, propagation, and arrest of the translation. The model simultaneously identifies the Sudete Mons / Thüringer Wald as a rigid-rotation block (dextral +35° about the Waltershausen pivot, 10°33′E / 50°53′N, inter-endpoint distance preserved within 2 %).

Version 7 introduces three structural improvements that further constrain the framework. **First**, the Ptolemaic *Abnoba Mons* is re-identified as a coherent pre-deformation crustal block encompassing the modern Taunus, Odenwald, Spessart, Rhön, and pre-Vogelsberg basement; fragmentation into separate modern ranges results from a $\sim -22°$ sinistral rotation of the southern portion about the *same* Waltershausen pivot that drives the Thuringian Forest. The pre-deformation positions of the *Rhenus Fluvius* source ($\sim$8.60°E / 50.06°N) and the *Danubius Fluvius* source ($\sim$8.96°E / 50.07°N) lie only $\sim$26 km apart — in precise agreement with the Mercator (1569) cartographic representation. **Second**, internal proportions in Ptolemy's coordinate system independently corroborate the Vistula = Lausitz identification: the Ptolemaic Harz–Vistula longitude ratio predicts a real-world distance of $\approx$325 km, which matches the Oder mouth ($\approx$300 km) and rules out the Polish Vistula ($\approx$620 km) as a 2× map stretch. **Third**, the trigger budget is revised on physical grounds: direct down-range coupling between the Saale-Unstrut impact lobe and the pre-shift Elster-Cluster positions makes SU the dominant translation driver ($\approx$50 %), with Český Kráter contributing $\approx$35 %, Africa/CDF $\approx$10 % (primarily pre-loading), and Bramsche $\approx$5 %.

Explicit, falsifiable criteria are defined through 34 specific tests (T1–T34), includ-

ing OSL dating, reflection-seismic profiling, $^{40}Ar/^{39}Ar$ age-gradient testing across the Vogelsberg, direct cartometric matching of Ptolemaic Rhenus/Danubius source coordinates, and isotope-hydrogeological confirmation of the artesian Ottendorf-Okrilla aquifer system.

Disclaimer

This manuscript presents an interdisciplinary working hypothesis. It formulates falsifiable predictions and is intended to stimulate further empirical testing. The Saale-Unstrut Fragment Impact, the postulated third event at Vogelsberg/Frankfurt, and the unified Abnobae block identification remain hypotheses not confirmed by current peer-reviewed literature. The model has not been evaluated by peer review.

2. Abstract (classical descriptive, supplementary)

The historical geography of *Germania Magna* is methodologically among the most demanding fields of classical studies and geodetic research. The currently dominant reference model (statistical-geodetic rectification of the TU Berlin group) explains deviations between Ptolemaic coordinates and modern topography primarily as measurement errors of ancient instruments or as transmission artefacts. The present work opposes this concept on two fronts: (i) the primary explanatory principle is the recognition that the northern reference line — the coastline of the *Oceanus Germanicus* — lay approximately 120 km further south during antiquity than today; (ii) real geodynamic processes (CDF reactivation, lateral extrusion, multi-layer décollement glide, rigid block rotation, and now the unified-Abnobae sinistral rotation) constitute a secondary, quantitatively investigated component requiring multi-layer kinematic treatment. The model is falsifiable through a battery of 34 explicit tests (T1–T34).

3. Introduction: Scope, Method, and Positioning

The historical geography of *Germania Magna* — the territory east of the Rhine and north of the Danube described by Claudius Ptolemy in the *Geographike Hyphegesis* (c. 150 AD) — constitutes one of the methodologically most demanding fields of classical studies and geodetic research.

The present model opposes the TU Berlin consensus on two fronts:

1. The *primary explanatory principle* is the recognition that the northern reference line — the coastline of the *Oceanus Germanicus* — lay approximately 120 km further south during antiquity than today. Version 6 introduced a formal *latitude bias parameter* $c = 15.2\,\mathrm{km}/^{\circ}_{P}$; Version 7 retains this and adds the Mercator-1569 cartographic match for the Rhenus/Danubius sources as an additional cross-check.

2. Real geodynamic processes — reactivation of the CDF, lateral extrusion, multi-

layer décollement glide, rigid block rotation, and (v7) the unified sinistral rotation of the southern Abnobae block — are a *secondary, quantitatively investigated* component that nonetheless requires multi-layer kinematic treatment.

The present unified work is structured in six thematic parts:

- **Part I:** General conceptual and interdisciplinary framework, including the ED-E hypothesis, cartometric reidentifications, kinematic taxonomy, southern Danubius anchor, latitude bias, multi-layer décollement hypothesis, impact structures, revised three-vector force model, Main-valley buckling kinematics, Cimbrian peninsula clarification, and the quantitative trigger budget.
- **Part II:** Cartometric transformation model with explicit mathematics; statistical residual analysis including the extended Elster Cluster ($n = 6$, $t = -19.1$, $df = 5$); bias-corrected residual table; Vistula=Lausitz proportional cross-check.
- **Part III:** Geophysical evidence base, including the Doberlug-Kirchhain pressure-cooker mechanism, Erzgebirge ore interference grid, and coal corridor SU–CK.
- **Part IV:** Saale-Unstrut Fragment Impact Hypothesis with revised G7 biaxial lateral extrusion model, updated plausibility assessment, and three-scenario impactor-size analysis.
- **Part V (new in v7):** Unified Abnobae Mons hypothesis, Waltershausen universal pivot, Rhenus/Danubius source identifications, and Vogelsberg/Wetterau pull-apart kinematics.
- **Part VI (new in v7):** Methodological defence (mathematical overdetermination, three principal objections).

Part I
General Model Description: Foundations, Mechanisms, and Interdisciplinary Framework

4. The Event-Dark-Earth (ED-E) as Catastrophic Sediment Archive

Ancient and medieval chronicles are treated in this model not as mere myths, but as precise observation protocols of real catastrophic natural events. Reports such as those by Michael the Syrian or Cosmas of Prague are therefore read as contemporary descriptions of climatic and geodynamic phenomena that modern scholarship has often minimised or dismissed as allegories. By directly correlating these textual testimonies with the physical **Event-Dark-Earth (ED-E)** archive, their credibility as records of

a genuine historical turning point in the 6th century is substantially strengthened.

4.1 Critique of the Gardening Theory

The conventional "gardening theory" for the origin of the dark soil layers is criticised on the grounds of its lack of social and economic plausibility during a phase of societal collapse. This theory assumes that populations in the 5th and 6th centuries devoted enormous labour resources to large-scale clearing, charcoal production, and systematic levelling in order to create garden plots — activities that appear entirely implausible in the face of the archaeologically attested settlement abandonment and demographic decline documented by Bemmann (2023) and Volkmann (2014). The conventional explanation is therefore considered explanatorily weak, because it requires numerous historically unattested auxiliary hypotheses to account for the uniform character of the layers.

4.2 The Gaberz Database and its Reinterpretation

A central empirical foundation is provided by Gaberz's (2014) diploma thesis *Dark Earth – die schwarze Schicht*, which catalogues dark, homogeneous soil horizons at numerous European sites in detail. Gaberz interprets them classically as the result of slow anthropogenic and natural processes (bioturbation, horticulture, settlement waste disposal). This model adopts her extensive database but reinterprets the **homogeneity** and the complete **absence of internal stratification** — features emphasised by Gaberz herself — as possible signatures of sudden, catastrophic deposition.

4.3 Falsifiable Predictions for the ED-E Horizon

As part of the testing framework, the following concrete, falsifiable predictions are formulated for an Event-Dark-Earth (ED-E) layer (Mildner, 2026):

P1. Chaotic homogeneity: Fine material and coarse debris chaotically mixed by high-energy processes, without internal lamination.

P2. Geochemical anomalies: Elevated Cl/Br ratios indicative of marine injections; elevated PAH content; anomalous cosmochemical markers (e.g., iridium, nickel, chondritic particle signatures).

P3. Heavy-mineral enrichment at the base ("soap effect"), consistent with hydraulic sorting by a high-energy flood pulse.

P4. Micromorphological evidence of impulsive mixing fabrics, absent in anthropogenic Dark Earth.

P5. In-situ thermal anomalies: Vitrifications or flash-heating signatures incompatible with domestic hearths.

P6. Synchronous abrupt collapse of the tree-pollen curve, temporally coincident with ED-E deposition — distinguishable from gradual anthropogenic clearing by its rapidity and absence of crop-pollen increase.

These features are explicit predictions of the ED-E catastrophe model and have not yet been confirmed as established findings in Gaberz's (2014) analyses. Targeted high-resolution micromorphological, geochemical, and palynological follow-up studies on existing Dark-Earth profiles are therefore required to test the hypothesis.

4.4 Palynology as Ecological Protocol

Palynology serves as a complementary "ecological protocol" that temporally and biologically validates the sediment data. While sediment analysis forensically demonstrates the physical character of the catastrophe, palynology records the biological consequence: an abrupt collapse of the tree-pollen curve in direct temporal association with the formation of the ED-E horizon. This rapid ecological "reset" is methodologically distinct from gradual anthropogenic clearing, which produces slower landscape changes accompanied by typical crop-pollen signals.

5. Reinterpretation of the 6th-Century Historical and Archaeological Record

5.1 The Collapse of the Thuringian Kingdom

This model interprets the collapse of the Thuringian Kingdom in 531 AD as the direct result of a major geodynamic and climatic catastrophe (Gregor of Tours, c.575; Bemmann, 2023). The historically documented Battle of the Unstrut zone falls directly within the postulated inner-ring zone of the Saale-Unstrut Fragment Impact, and the Thüringer Wald constitutes the structural southern outer rim of the postulated crater (§11).

5.2 Scandia: An Island Massif in Mecklenburg-Western Pomerania

Scandia (Skandza) in this model is not the Scandinavian peninsula but a topographically limited island massif in present-day Mecklenburg-Western Pomerania. The *Blinkerwall* discovery — a 971-metre-long submerged Stone Age hunting architecture at 21 m water depth in the Bay of Mecklenburg (Geersen et al., 2024) — corroborates the multi-phase geomorphological evolution.

6. Cartometric Reinterpretation of Ptolemy's Map and Key Geographical Reidentifications

6.1 The Affine Transformation and the Global Scaling Factor

Apparent "errors" in medieval maps, including the Ptolemy map rendered by Donnus Nicolaus Germanus, are not scribal mistakes but faithful records of the pre-catastrophe

landscape. A fixed global scaling factor of approximately 28 km per degree of longitude is applied, anchored on the invariant Rhine–Elbe baseline. The mathematical transformation is expressed as:

$$\lambda_{\text{local}} = \lambda_{\text{Ptolemaeus}} - (\Delta\lambda_{\text{Offset}} \times k) \tag{1}$$

where k compensates for historically conditioned stretching. The complete affine transformation — consisting of translation, rotation, and uniform scaling — aligns the ancient coordinates precisely with modern topography once tectonic shifts are accounted for. The minimisation objective for the least-squares adjustment over all n gazetteer points is:

$$S = \sum_{i=1}^{n} w_i \left[\Big(E_i - f(\lambda_i, \phi_i)\Big)^2 + \Big(N_i - g(\lambda_i, \phi_i)\Big)^2 \right] \tag{2}$$

where w_i represents the weighting according to Ptolemaic measurement accuracy.

The scaling factor of approximately 28 km per Ptolemaic degree is derived directly from Ptolemy's coordinates of the invariant Rhine–Elbe baseline and its eastward extension to the *Vistula Fluvius* (re-identified as the Lausitz river system). Ptolemy records:

$$\begin{aligned}
\text{Central mouth of Rhenus Fluvius:} &\quad \lambda = 27^\circ 00', \ \phi = 53^\circ 10' \\
\text{Mouths of Albis Fluvius (Elbe):} &\quad \lambda = 31^\circ 00', \ \phi = 56^\circ 15' \\
\text{Mouths of Vistula Fluvius (Lausitz system):} &\quad \lambda = 45^\circ 00', \ \phi = 56^\circ 00'
\end{aligned}$$

Two independent baseline estimates yield $k \approx 28\,\text{km}$ per Ptolemaic degree of longitude. The complete mathematical formulation is given in §20.

Modern geographic distances yield two independent baseline estimates:

$$k_1 = \frac{\approx 115\,\text{km}}{4^\circ} \approx 28.75\,\frac{\text{km}}{\text{degree}} \tag{3}$$

$$k_2 = \frac{\approx 490\,\text{km}}{18^\circ} \approx 27.22\,\frac{\text{km}}{\text{degree}} \tag{4}$$

Averaging these independent baselines produces the robust global scaling factor of ≈28 km per Ptolemaic degree of longitude. The full derivation, matrix solution, and parameter values are presented in Section 19.

6.2 Key Geographical Reidentifications

Key geographical reidentifications follow directly from the rectified grid (Mildner, 2025/2026, 2026):

The Vistula Fluvius as the Lausitz River System. The *Vistula Fluvius*, described by Ptolemy as a river with two major arms originating south of the *Asciburgius Mons* and converging east of it, is identified as the Lausitz river system (Schwarze Elster–Spree–Oder) rather than the modern Polish Vistula. Projecting the *Vistula Fluvius* onto the modern Polish Vistula destroys mathematical consistency, forces massive local distortions that violate topological integrity, and eliminates predictive power for landmarks such as *Melibocus Mons* or structures in the Saxon Ore Mountains.

The Asciburgius Mons as the Fläming. The *Asciburgius Mons* is re-identified as the Fläming (not the Riesengebirge). Its distinctive "kink" on ancient maps matches the tectonic bend visible today and corresponds to a tectonic hinge massively consolidated by compressive forces of the Alps/Carpathian orogeny. This structural density created a natural baffle and barrier during transient events such as tsunami waves or impulse floods.

The Danubius Fluvius as the modern Main. The *Danubius Fluvius* at the southern border of *Germania Magna* is identified with the modern Main river. In v7, the pre-deformation source of the Danubius was located at approximately 8.96°E / 50.07°N (see §50), and the modern source position has shifted by ∼55 km ESE through the sinistral rotation of the unified Abnobae block.

Scandia as an Island Massif in Mecklenburg. Scandia in this model is not the Scandinavian peninsula but a topographically limited island massif in present-day Mecklenburg-Western Pomerania (see Section 5 and Section 35).

6.3 The Cimbrian Peninsula Reconsidered (new in v7)

The ancient Cimbrian Peninsula is not modern Jutland

According to the present model, the *Cimbric Chersonese* in antiquity was a promontory extending along the Lüneburg Heath as far as the modern Baltic coast, encompassing only the southern part of present-day Schleswig-Holstein and the eastern part of Mecklenburg. Its tip was situated in the region south of the Bay of Mecklenburg and *is not to be equated with the modern conception* of the Cimbrian Peninsula (which comprises Jutland/Denmark and the northern part of Schleswig-Holstein).

This re-identification is geometrically required by the ≈120 km southward position of the antique *Oceanus Germanicus* coastline: with the coastline at ∼52°50′N rather than

at the modern North Sea / Baltic position, the ancient "peninsula" visible to classical geographers terminated at the Mecklenburg Bay margin, with Lüneburg Heath forming its land-side neck. The modern Jutland was, in this configuration, a more distal island/ peninsula system not directly addressed in the Ptolemaic description.

6.4 Vistula = Lausitz: Proportional Cross-Check (new in v7)

Independent decisive cartometric argument

Based on Ptolemy's original coordinates, the Vistula sits roughly 1.25× further east of the Harz mountains than the Harz sits from the Rhine. When translated into real-world distances using the Rhine and the central Harz as reference points, this historical ratio predicts a distance of approximately **325 km between the Harz and the Vistula mouth**. The actual distance from the Harz to the mouth of the Oder River (Mildner's model) is about **300 km**, which represents a remarkably close match. Conversely, the distance to the mouth of the Weichsel River (Lelgemann model) is nearly double the predicted amount at roughly **620 km**. Consequently, the internal proportions of Ptolemy's map strongly support locating the ancient Vistula at the Oder River; placing it at the Weichsel would introduce an unjustifiable and massive stretching of the entire coordinate system.

This argument is **decisive because it does not depend on any geodynamic interpretation**: it tests the internal consistency of Ptolemy's own coordinate ratios against the two competing identifications. The Mildner/Oder model matches; the Lelgemann/Polish-Vistula model fails by a factor of two.

6.5 The Elster Cluster: Budorigum, Limis Lucus, Lugidunum, Stragona (updated in v7)

The four core Ptolemaic place names show $\overline{\Delta\lambda} = -93.1\,\text{km}$ ($t = -13.7$, $p < 0.001$, $df = 3$). With the three new identifications introduced in v7 (Leukaristos, Arsonion, Carrodunum), the improved test yields $t = -19.1$, $df = 5$ (see §8.2.2).

Core Cartometric Result (v7: extended)

The Elster Cluster (6 points) is displaced on average **91.4 km eastward** relative to the affine model prediction ($t = -19.1$, $p \ll 0.001$, $df = 5$). This is incompatible with uniform measurement error and requires a geodynamic, tectonic-block explanation: *translation-glide* of the sediment cover along a basal Zechstein décollement toward the Lausitz backstop. The Arsonion identification additionally localises the décollement tip at ∼15–25 km west of the Lausitz Granodiorite contact.

7. The Danubius Fluvius as Southern Validation Anchor: Latitude Bias Parameter and Source-Position Resolution

7.1 The Southern Calibration Gap in Earlier Versions

Versions 1–5 calibrated the affine transformation exclusively on three northern anchor points (Rhine, Elbe, Vistula mouth), all lying on the coastline of the *Oceanus Germanicus*. The most visible expression of the resulting predictive bias in v5 was the G8 residual ($\Delta\phi = +91.2\,\text{km N}$).

7.2 V7 update: source-position resolution

The Danubius source-region anchor K4 (Abnobae Mons W / Taunus, $\lambda_M = 7.867°\text{E}$, $\phi_M = 50.017°\text{N}$) is retained as the *western terminus* of the unified pre-deformation Abnobae Mons. The actual *source* of the Danubius itself, however, lay at the *eastern* end of this unified massif at approximately $\lambda \approx 8.96°\text{E}$, $\phi \approx 50.07°\text{N}$ (pre-deformation) — ∼26 km east of the also pre-deformation Rhenus source (§51). This refinement preserves K4 as a valid calibration anchor while clarifying that the "Danubius source" Ptolemy describes is a distinct geographical point at the eastern terminus of the same massif.

7.3 Formalisation of the Latitude Bias Gradient

The latitude bias can be parameterised as a linear gradient over the Ptolemaic latitude coordinate ϕ_P:

$$\Delta\phi_{\text{bias}}(\phi_P) = c \times (\phi_{\text{ref}} - \phi_P) \tag{5}$$

where $\phi_{\text{ref}} \approx 55°$ is the effective reference latitude of the northern calibration cluster (bracketed between the Rhenus mouth at $\phi_P = 53.17°$ and the Albis/Vistula at $\phi_P \approx 56°$), and c is the bias gradient in km per Ptolemaic degree. The bias is applied only when $\phi_P < \phi_{\text{ref}}$.

$$\Delta\phi_{\text{bias}}(\phi_P) = c \times (\phi_{\text{ref}} - \phi_P), \quad \phi_{\text{ref}} \approx 55°, \quad 3.16 \le c \le 15.2\ \text{km}/^\circ_P \tag{6}$$

Physical interpretation of c

The bias gradient c quantifies how many kilometres of systematic northward overprediction per Ptolemaic degree of latitude the northern-only calibration introduces. A larger c implies a stronger coastline-shift effect on the inland residuals. The theoretically expected range of c is constrained by the two-point southern calibration system described in §22 (Part II): $3.16 \le c \le 15.2\,\text{km}/^\circ_P$.

7.4 Adoption of $c = 15.2\,\mathrm{km}/^{\circ}_{P}$ as Main Scenario

The main scenario adopted in v6 is $c = 15.2\,\mathrm{km}/^{\circ}_{P}$, corresponding to the constraint that G8 (Abnobae Mons West, Taunus / Großer Feldberg) is *fully explained* by the coastline-shift bias with zero residual tectonic northward displacement of the Taunus block. Under this scenario:

- G8 bias: $15.2 \times (55 - 49) = 91.2\,\mathrm{km} \Rightarrow$ G8 corrected residual $= 0$ (fully absorbed into bias).
- G6 (Sudete Mons E) bias-corrected: $\Delta\phi_{\mathrm{corr}} = +71.6 - 76.0 = -4.4\,\mathrm{km} \Rightarrow r_{\mathrm{corr}} = 12.0\,\mathrm{km}$ (near-perfect prediction of the post-rotation position).
- EC SSE component: net $-16.1\,\mathrm{km}$ S, marginally significant ($p \approx 0.035$, $df = 3$), consistent with CDF-driven extrusion from NNW.

The adoption of this scenario is justified on three independent grounds: (a) geological: the Taunus block is geologically stable (Variscan basement upthrust, no 6th-century tectonic mobility indicator); (b) geometric: the Sudete rotation prediction matches within 12 km — an exquisite internal consistency; (c) statistical: it produces a significant SSE signal in the Elster Cluster, independently motivating the CDF-extrusion interpretation.

The full trade-off table between c and other model parameters is given in Part II (§22).

Summary: Under $c = 15.2\,\mathrm{km}/^{\circ}_{P}$: G8 corrected residual = 0 (bias fully absorbed); G6 corrected residual $r_{\mathrm{corr}} = 12.0\,\mathrm{km}$; EC SSE component $= -16.1\,\mathrm{km}$ ($p \approx 0.035$).

7.5 G8 Promoted to K4: Taunus as Fourth Calibration Reference

K4: Taunus / Danubius Source Region

K4 (Abnobae Mons W / Taunus): $\lambda_M = 7.867°\mathrm{E}$, $\phi_M = 50.017°\mathrm{N}$; $\lambda_P = 31°$, $\phi_P = 49°$. Bias-corrected residual: $\Delta\phi_{\mathrm{corr}} = 0.0\,\mathrm{km}$ (calibration anchor). Residual longitude: $\Delta\lambda_{\mathrm{km}} = +11.2\,\mathrm{km}$ (within measurement uncertainty). **Important v7 distinction: K4 (Taunus, stable Rhenohercynian block) ≠ G9 (Danubius source, mobile MCZ/Saxothuringian block).**

7.6 Geometric Verification: Sudete Rotation via Danubius Proximity

A structurally elegant consequence of introducing the Danubius as reference line emerges from examining the change in distance between the Sudete Mons eastern endpoint (G6) and the Danubius reference latitude:

Pre-rotation (Ptolemaic):

$$\Delta\phi_{\text{Sudete-Danubius}} = \phi_P(\text{Sudete}) - \phi_P(\text{Danubius W}) = 50^\circ - 48.5^\circ = 1.5^\circ$$

$$\Rightarrow \quad \approx 54\,\text{km (in Ptolemaic scale)}$$

Post-rotation (modern):

$$\Delta\phi_{\text{G6-Danubius}} = 50.367^\circ - 50.0^\circ \approx 0.37^\circ \approx 41\,\text{km}$$

The +35° dextral rotation reduced the Sudete–Danubius spacing from ≈110–120 km (pre-rotation, bias-corrected) to ≈30–40 km (post-rotation). The Waltershausen-pivot rotation model with lever arm $r \approx 90$ km to the SE terminus (G6) predicts a chord displacement of:

$$\Delta s_{G6} = 2\,r\,\sin\left(\frac{35^\circ}{2}\right) = 2 \times 90 \times \sin(17.5^\circ) \approx 54\,\text{km southward} \tag{7}$$

The predicted ≈54 km southward sweep of the SE terminus matches the observed approach of G6 to the Danubius reference line (≈110–120 km pre-rotation → ≈30–40 km post-rotation, Δ ≈50–80 km) within the combined identification uncertainty of ±15–50 km. This constitutes an *independent geometric verification* of the block-rotation model using the Danubius as external reference structure.

7.7 The Pre-Deformation Parallelism of Sudete Mons and Danubius

Both structures share the same W–E orientation in Ptolemy's coordinates: the Sudete Mons at $\phi_P = 50^\circ$ and the Danubius at $\phi_P \approx 48.5^\circ$. Pre-deformation parallelism implies that the Thuringian Forest originally formed the northern ridgeline above the Main/Danubius headwater region — a geologically plausible configuration. The +35° dextral rotation disrupted this parallelism by rotating the eastern Sudete terminus southward toward the Danubius reference line, reducing the pre-rotation gap from ≈110 km to ≈30 km in absolute distance. The Danubius as reference structure makes this kinematic consequence *directly measurable and independently falsifiable.*

7.8 The Anduaetium / Bamberg Hypothesis as Secondary Danubius Anchor

Uncertainty caveat for Anduaetium / Bamberg

The following identification is offered as a *highly uncertain, hypothetical secondary anchor* with an estimated position uncertainty of ± ≈ 100 km. The region has been massively geodynamically overprinted. The hypothesis is included as a model-improvement test with predictive value for future residual analysis; it is not a confirmed anchor.

Ptolemy's *Geographike Hyphegesis* (Book II, Ch. 10) lists the settlement **Anduaetium** (Ancient Greek: ἀνδουαίτιον) at Ptolemaic coordinates $\lambda_P = 40°30'$ and $\phi_P = 47°40'$. At this latitude ($\phi_P \approx 47.67°$) the settlement lies in the Ptolemaic Danubius / southern Barbaricum zone, close to the Main/Danubius contact region of the model.

Applying the v6 affine transformation gives a model prediction:

$$\hat{\lambda}_{\text{mod}} = -8.114 + 0.3989 \times 40.5 + 0.0770 \times 47.67 \approx 11.71°\text{E}$$
$$\hat{\phi}_{\text{mod}} = 35.458 - 0.0167 \times 40.5 + 0.3244 \times 47.67 \approx 50.25°\text{N}$$

This falls in the Thüringian Schiefergebirge / upper Saale region. The modern Bamberg area (Regnitz–Main confluence area, ≈ 49.89°N / 10.89°E; note that Bamberg is located on the Regnitz river approximately 3 km upstream of its confluence with the Main) lies ≈ 95 km SSW of this prediction. The residual:

$$r_{\text{Anduaetium}} \approx \sqrt{59^2 + 40^2} \approx 71\,\text{km} \tag{8}$$

is large, but the geographic note in the sources suggests that the original settlement may have been displaced *eastward* toward the Český Kráter by the impact loading — i.e., the modern Bamberg area may represent the *pre-impact* position, which was subsequently shifted eastward. Under this interpretation, the ≈ 71 km residual reflects a geodynamic displacement of Anduaetium eastward toward the CK structure during the 6th-century deformation episode.

The bias-corrected displacement vector at Anduaetium (≈59 km E, ≈72 km N after bias correction, total ≈95 km towards NNE) carries contributions from both the biaxial stress field and the Český Kráter's combined eastward and northward forcing. The two components are not inconsistent: eastward λ-displacement is the Český Kráter downrange vector (§15), while the residual northward ϕ-displacement reflects additional lateral forcing perpendicular to the biaxial corridor axis. Both are physically plausible but speculative given the large identification uncertainty.

The biaxial stress field between Bramsche and Český Kráter would have subjected the Maindreieck region to a strongly heterogeneous deformation, consistent with the observed large uncertainty. Bamberg / the Regnitz–Main confluence area is provisionally adopted as a plausible candidate location for Anduaetium, pending targeted archaeological investigation (falsification test T10, §57).

Structural position of Anduaetium in the biaxial stress field

In Ptolemy's biaxial framework, Anduaetium at $\phi_P = 47.67°$ lies on the biaxial tension zone of the Bramsche–Český Kráter axis, approximately equidistant from both stress sources. The original settlement would have been in a region of maximum biaxial shear strain — mechanically consistent with a large displacement uncertainty (±100 km) because the deformation gradient is steep and anisotropic. This is not an arbitrary uncertainty but a *physically motivated* one.

8. Kinematic Classification of the Deformed Blocks: Translation-Glide vs. Rigid Rotation

8.1 Diagnostic Test: Pivot–Distance Conservation

For a putative rigid rotation around a pivot P, every point x_i of the block must satisfy $d(x_i^{\text{pre}}, P) = d(x_i^{\text{post}}, P)$ within the cartometric uncertainty (±15 km for settlements, ±50 km for mountain endpoints).

$$d(x_i^{\text{pre}}, P) \;=\; d(x_i^{\text{post}}, P) \quad \forall\, i \tag{9}$$

8.2 The Elster-Cluster: A Translation-Glide Block with SSE Component

Table 1: Pivot-distance test for the core Elster-Cluster. All four core points approached Senftenberg by ∼88 km, ruling out rigid rotation.

Point	d_{pre} to Senftenberg (km)	d_{post} (km)	Δd (km)
Budorigum (S3)	122	30	−92
Limis Lucus (S5)	135	60	−75
Lugidunum (S6)	142	49	−93
Stragona (S7)	145	55	−90
Mean	136	48.5	**−88**

Result: Elster-Cluster is a translation-glide block

Translation-glide of the Elster-Cluster sediment cover approximately ENE (∼93 km, azimuth ≈ 100°) along a basal décollement, with the **Lausitzer Granodiorite Block as rigid backstop**.

8.2.1 The SSE Component of the Elster Translation

Under $c = 15.2\,\text{km}/^\circ_P$, the bias-corrected $\Delta\phi$ residuals of the four Elster-Cluster points reveal a marginal but consistent *southward* component:

Table 2: Bias-corrected latitude residuals of the Elster Cluster under $c = 15.2\,\mathrm{km}/^{\circ}_{P}$.

Point	$\Delta\phi_{\mathrm{obs}}$ (km)	Bias ($c \times \delta$, km)	$\Delta\phi_{\mathrm{corr}}$ (km)
S3 Budorigum	+26.9	−35.4	−8.5
S5 Limis Lucus	+9.2	−22.8	−13.6
S6 Lugidunum	+24.5	−38.0	−13.5
S7 Stragona	+11.8	−40.6	−28.8
Mean	+18.1	−34.2	**−16.1**
SD	8.9	8.3	8.8

$$t_{\phi} = \frac{-16.1}{8.8/\sqrt{4}} = -3.66, \quad p \approx 0.035 \; (df = 3, \text{ one-tailed}) \tag{10}$$

The Elster-Cluster translation thus has a **marginally significant southward component of** $-16.1 \pm 4.4\,\mathbf{km}$ (1σ), corresponding to an effective translation azimuth of $\approx 100^{\circ}$ (ENE–SSE rather than pure ENE).

Mechanical explanation. The CDF reactivation drives lateral extrusion of Cimbrian Peninsula sediments from NNW. For a CDF extrusion azimuth of $\approx 150^{\circ}$–160° (SSE), the full southward component of Vector A would be 32–36 km, but three effects reduce this to the observed −16.1 km: (a) The Zechstein décollement dip-direction filters the motion vector toward ENE; (b) The Český Kráter SE-compression contributes a northward force opposing the southward component; (c) The Lausitz backstop reaction has a northward component. The resulting net southward signal of −16.1 km is quantitatively consistent with partial CDF-extrusion dominance ($\approx 50\%$ of the full geometric southward component preserved after directional filtering), confirming the CDF as an active contributor to the translation kinematics. Under $c = 15.2\,\mathrm{km}/^{\circ}_{P}$, the bias-corrected $\Delta\phi$ residuals yield a net southward component of -16.1 ± 4.4 km ($t_{\phi} = -3.66$, $p \approx 0.035$, $df = 3$), corresponding to translation azimuth $\approx 100^{\circ}$.

8.2.2 Extended Cluster: Leukaristos, Arsonion, Carrodunum (new in v7)

Three new identifications completing the kinematic picture

Leukaristos ($\lambda_P = 41°30'$, $\phi_P = 52°40'$) → Finsterwalde (13.717°E / 51.633°N): $\Delta\lambda = -87.4$ km. Elster Cluster member; confirms the cluster's eastern boundary.

Arsonion ($\lambda_P = 43°30'$, $\phi_P = 52°20'$) → Senftenberg zone, mid-point (13.989°E / 51.556°N): $\Delta\lambda = -51.5$ km. **Décollement transition zone** — geometrically localises the Zechstein abscherfront (tip of the décollement) at ∼15–25 km west of the Lausitz Granodiorite contact.

Carrodunum ($\lambda_P = 42°40'$, $\phi_P = 51°30'$) → Spreetal/Nochten area (14.060°E / 51.420°N): $\Delta\lambda = -85.0$ km. Elster Cluster member; fills the gradient gap at $\Delta\lambda \approx -85$ km.

The keltisch-etymology of *Carrodunum* (*carro + dunum = "fortified wagon-place") is consistent with the *Billendorfer Kultur* ringwall sites (Ostroer Schanze, Dubringer Moor) documented in the archaeological record of the region; the Schwepnitz Denarius hoard (Nero–Marcus Aurelius, terminus post quem 164 AD) provides direct Roman-period confirmation of settlement activity in the Kamenz – Hoyerswerda zone during Ptolemy's source period.

8.2.3 Coulomb-Wedge Gradient: Physical Interpretation of Arsonion

The displacement field across the Senftenberg-zone reveals a two-stage transition from backstop to fully-displaced block:

Table 3: Translation gradient from Lausitz backstop to Elster-Cluster core, demonstrating the Coulomb-wedge structure of the décollement. All $\Delta\lambda$ values in km (eastward negative).

Point / Zone	$\Delta\lambda$ (km)	role
K3 Backstop (Senftenberg/Oderberg)	≈ 0	rigid backstop
S4 Calisia (Calau)	−38.2	backstop-proximal zone
S-A Arsonion (Senftenberg zone)	**−51.5**	**décollement tip / abscherfront**
S-C Carrodunum (Spreetal)	−85.0	rigid block onset
S-L Leukaristos (Finsterwalde)	−87.4	rigid block core
S3 Budorigum (Doberlug-Kirchhain)	−87.1	rigid block core
S7 Stragona (Herzberg/Elster)	−101.0	rigid block core
S6 Lugidunum (Falkenberg/Elster)	−109.5	rigid block core

The **jump from ∼52 km (Arsonion) to ∼85 km (Carrodunum)** at similar spatial distances from the backstop documents the **décollement tip**: the Zechstein evaporite abscherfront, beyond which the overlying sediment cover decoupled and moved as a

rigid body. This kinematic structure is mechanically identical to an accretionary prism tip in modern subduction zones.

8.3 The Sudete-Mons Block: Rigid Rotation with Revised Pivot

The two Ptolemaic endpoints of the Sudete Mons share exactly $\phi_P = 50°00'$. The distance-preservation test (Table 4) confirms +35° dextral rotation. The modern equivalent descends south-eastward; the corresponding strike change of +35° (dextral/clockwise) is confirmed by the distance-preservation test).

Table 4: Geometric audit of the Sudete-Mons block.

Quantity	Ptolemaic (pre-rotation)	Modern (post-rotation)
Sudete-W coords	34°E / 50°N	9.583°E / 51.233°N
Sudete-E coords	40°E / 50°N	11.533°E / 50.367°N
Inter-endpoint distance	$6° \times 27.5$ km/° = 165 km	$\sqrt{137^2 + 96^2} = 167$ km
Strike azimuth	90°(W–E)	125°(ESE)
Rotation ΔAzimut	—	**+35°** (dextral)

Result: rigid dextral rotation about the Waltershausen hinge

The 165–167 km inter-endpoint distance is preserved within <2 % — the hallmark of rigid-body rotation. The dextral rotation angle of +35° (≈34–35° from the NW-terminus chord; ≈35° from the azimuth change of the block) is confirmed. The pivot is identified as a central block hinge at approximately **Waltershausen** (10°33′E / 50°53′N), the north-western structural front of the Thüringer Wald crystalline basement, ≈83 km from the Saale-Unstrut outer-ring centre (Stolberg): the block rotated about its own near-midpoint, with the NW end (G5, Neukirchen pre-position) sweeping ≈52 km northward to the Kassel area, and the SE end (G6) sweeping ≈54 km southward to the Lobenstein area.

8.4 Summary of the Kinematic Taxonomy

Table 5: Kinematic classification of the principal blocks. T-G = translation-glide; R = rigid rotation; T-G+r = predominantly translation with subordinate rotation. **Updated in v6**: G7, G5, and SSE component.

Block	$\overline{\Delta\lambda}$	$\overline{\Delta\phi}$	Class	Pivot / Anchor
Lausitzer Granodiorite	≈ 0	≈ 0	—	rigid backstop
Elster-Cluster (sed. cover)	−93	−16 (corr.)	**T-G (SSE)**	Lausitz backstop, az. $\approx 100°$
G7 Sarmate Mons N	−94	+71 (corr.)	**T-G + biax. extrusion**	on SU–CK axis ($d_\perp = 5.2$ km)
K4/G8 Abnobae Mons W	+11	0 (corr.)	**K4 anchor**	Danubius source (bias-cal.)
Asciburgius (Fläming)	−39	+18	T-G+r	décollement-decoupled
Melibocus E (Harz)	−41	+39	T-G+r	internal rot. ∼15°
Melibocus W (Weser-Leine)	−23	−7	ductile end	lateral extrusion
Sudete-Mons block	Δstrike + 35°	—	**R (dextral)**	Pivot: Waltershausen (10°33′E / 50°53′N); G5 = NW mobile terminus (lever arm ≈86 km, sweeps ≈52 km N); G6 = SE mobile terminus (lever arm ≈90 km, sweeps ≈54 km S); pivot at near-block-centre; rotation-corrected residuals: G5 ≈11 km, G6 ≈0.1 km

8.5 G7 (Sarmate Mons N): Biaxial Lateral Extrusion

Under $c = 15.2\,\mathrm{km}/^\circ_P$: $\Delta E = +93.9$ km, $\Delta N = +70.6$ km; azimuth 53.0° vs. expected 44.4° ($\Delta\theta = 8.6°$, within ±10–15°). Pre-deformation G7 position only $d_\perp = 5.2$ km from the SU–CK compression axis.

8.6 V7 Unified Extension: Counter-Rotation of Southern Abnobae about the Same Waltershausen Pivot

Kinematic discovery: a single universal pivot for two counter-rotating blocks

The Waltershausen pivot $P \approx 10°33'\text{E} / 50°53'\text{N}$ established in v6 for the $+35°$ dextral rotation of the Sudete Mons block is shown in v7 to simultaneously serve as the pivot for a $\sim -22°$ *sinistral* rotation of the southern Abnobae block (Taunus–Odenwald–Spessart–Rhön complex). The lever arms from P to the two pre-deformation control points (Rhenus source at 8.60°E / 50.06°N and Amorbach reference) are both $\sim$166 km — almost identical to the $\sim$165 km lever arm to the Elster-Cluster centroid. This near-equality of radii at a single pivot point, combined with the dual sense of rotation (CW + CCW), is the geometric signature of a **positive flower structure** over an impulsive deformation centre and is the principal new kinematic finding of v7.

Full quantitative derivation in Part V (§51).

8.7 Summary of the Kinematic Taxonomy (v7-updated)

Table 7: Updated kinematic classification of the principal blocks. T-G = translation-glide; R = rigid rotation; T-G+r = predominantly translation with subordinate rotation. **New in v7**: Abnobae unified southern block; Vogelsberg/Wetterau pull-apart filling; extended Elster Cluster; Arsonion décollement-tip.

Block	$\overline{\Delta\lambda}$ (km)	$\overline{\Delta\phi}$ (km)	Class	Pivot / Anchor
Lausitzer Granodiorite	≈ 0	≈ 0	—	rigid backstop
Arsonion zone (new v7)	-52	—	T-G transition	décollement tip; Coulomb wedge
Elster-Cluster (sed. cover)	-93	-16 (SSE)	**T-G (SSE)**	Lausitz backstop, az. $\approx 100°$
G7 Sarmate Mons N	-94	$+71$	T-G + biax. extr.	SU–CK axis ($d_\perp = 5.2$ km)
K4/G8 Abnobae Mons W	$+11$	0	K4 anchor	Danubius source-region (bias-cal.)
Asciburgius (Fläming)	-39	$+18$	T-G+r	décollement-decoupled
Melibocus E (Harz)	-41	$+39$	T-G+r	internal rot. $\sim 15°$
Melibocus W (Weser-Leine)	-23	-7	ductile end	lateral extrusion
Sudete-Mons block	Δstr. $+35°$	—	R (dextral)	Pivot: Waltershausen ($10°33'$E / $50°53'$N); lever arms $\sim$86, $\sim$90 km
Southern Abnobae block (NEW)	$\sim+63$ (ESE disp.)	—	R (sinistral, $\sim -22°$)	Same Waltershausen pivot; lever arm $\sim$166 km (Amorbach); $\sim$55 km (Marktheidenfeld)
Vogelsberg/Wetterau (NEW)	—	—	pull-apart filling	Mio. basaltic fill of widening gap; 6th-c. possible phreatomagm. reactivation

9. Multi-Layer Kinematics: the Zechstein-Décollement Hypothesis

Table 9: Stratigraphic differentiation of translation amplitudes. The factor-2.4 ratio is direct cartometric evidence for a basal décollement.

Layer	Representative points	$\overline{\Delta\lambda_{\mathrm{km}}}$
Cover (Layer A: settlements)	S3, S5, S6, S7	$\mathbf{-93}$
Cover/Basement (Layer B: Fläming Mons)	G1, G2	$\mathbf{-39}$
Basement (Layer C: Lausitzer Granodiorite)	anchor	≈ 0

The factor-2.4 ratio between settlement displacements (−93 km) and basement (Fläming, −39 km) is direct cartometric evidence for a basal décollement. The Zechstein evaporite horizon ($k_{\mathrm{NaCl}} \sim 10^{-21}\,\mathrm{m}^2$; Urai et al. 1986) at 1–3 km depth throughout the Saale-Unstrut Triassic Lands and Niederlausitz (Scheck-Wenderoth et al., 2008) is the most likely candidate.

Mechanical consequence

The −93 km Elster-Cluster displacement represents the displacement of the *sedimentary cover above the Zechstein décollement*. The basement moved only ∼40 km. The factor-2.4 difference is direct cartometric evidence for an actively functioning Zechstein décollement during the 6th-century deformation episode.

10. Cometary Signatures and Impact Structures: The Český Kráter

Rajlich (2007); Rajlich et al. (2009) documented a giant multi-ring astrobleme centred in the Bohemian Massif with UHP evidence (pseudotachylite breccia veins, shocked quartz with PDFs, microdiamonds, moissanite, coesite; Klokočník et al. 2010). A substantially younger age (≈525–531 AD) is proposed; the GISP2 ice core (Abbott et al., 2014) records four discrete chondritic particle horizons in 533–540 AD as direct cosmochemical confirmation of a fragmented cometary source.

11. The Saale-Unstrut Fragment Impact: Crater Geometry and Primary Local Driver

11.1 V7 Update: SU as Primary Elster-Translation Driver (Revised Attribution)

The revised trigger budget (§14) attributes ≈50 % of the Elster-Cluster translation to direct SU down-range coupling. Physical justification:

- Pre-shift positions of the Elster Cluster (centred at ∼11.9–12.2°E, ∼51.6–52.0°N) lie only 40–90 km ESE of the SU inner crater centre (Geiseltal, 11.73°E / 51.33°N) — within the direct down-range deformation lobe.
- SU kinetic energy $E_{k,\mathrm{SU}} \approx 4.9 \times 10^{21}$ J (for a 2.5 km stony impactor at 20 km s^{-1}) approaches the order of the total estimated translation work $W_{\mathrm{tr}} \approx 6 \times 10^{21}$ J; energy ratio $E_{k,\mathrm{SU}}/W_{\mathrm{tr}} \approx 0.8$.
- At distance ∼80 km from SU, the regional stress contribution from a 10 km Africa impactor at >1000 km is smaller than SU's contribution by a factor >10.

12. The Geometry of the Sudete Rotation: Pivot and Lever-Arm Computation

12.1 V7 Unification Statement

The Waltershausen pivot is now established as the **universal pivot** for the two counter-rotating blocks of the post-531 AD deformation event. Its location at $P \approx 10°33'\mathrm{E} / 50°53'\mathrm{N}$, on the southern outer rim of the postulated SU deformation field, cannot be explained as coincidence: it is the geometrically required flower-structure pivot of an impulsive deformation event centred on the Geiseltal–Stolberg zone. The block to its NNE (Sudete Mons / Thüringer Wald) rotated dextrally +35° CW; the block to its SSW (southern Abnobae Mons, unified) rotated sinistrally ∼−22° CCW. The intermediate zone (Thüringer Becken) experienced maximum bookshelf-shear strain between these two counter-rotating blocks.

12.2 Pivot and Lever-Arm Geometry

The geometric rotation pivot, derived from the combined block motion of both endpoints G5 and G6 (§12.3.1), is at:

$$P \approx 10.542°\,\mathrm{E} \,/\, 50.882°\,\mathrm{N} \quad \text{(Waltershausen, NW Thüringer Wald structural front)} \tag{11}$$

The pivot lies ≈83 km from the Saale-Unstrut outer-ring centre (Stolberg), placing it on the *southern outer rim* of the postulated SU impact structure. The block rotated about this rim boundary with almost equal lever arms to both termini:

Table 10: Geometric consistency of the rotation about the Waltershausen pivot.

Quantity	Value	Assessment
Lever arm P to G5 (NW terminus, Neukirchen pre-pos.)	$\approx 86\,\mathrm{km}$	G5 essentially due west of P
Lever arm P to G6 (SE terminus, inferred pre-pos.)	$\approx 90\,\mathrm{km}$	G6 essentially due east of P
Pre-rotation G5 latitude	$\approx 50°53'\mathrm{N}$	≈same as P; block ran E–W
Pre-rotation G6 latitude	$\approx 50°49'\mathrm{N}$	≈same as G5; E–W block confirmed
$d(P$, Stolberg)	$\approx 83\,\mathrm{km}$	On southern outer rim: natural rotation boundary
G5 chord displacement ($\theta = 35°$)	$\approx 52\,\mathrm{km}$ N	(obs. ≈48–52 km)
G6 chord displacement ($\theta = 35°$)	$\approx 54\,\mathrm{km}$ S	(obs. ≈54 km)
G5 rotation-corrected residual	$\approx 11\,\mathrm{km}$	within ident. uncertainty
G6 rotation-corrected residual	$\approx 0.1\,\mathrm{km}$	essentially exact

For the Saale-Unstrut angle-equivalent of $\approx 19°$ (≈55 % of the rotation budget; §14):

$$\Delta s_{\mathrm{SU,G5}} = 2 \times 86\,\mathrm{km} \times \sin(9.5°) \approx 28\,\mathrm{km}\ \text{northward (NW terminus)} \tag{12}$$

$$\Delta s_{\mathrm{SU,G6}} = 2 \times 90\,\mathrm{km} \times \sin(9.5°) \approx 30\,\mathrm{km}\ \text{southward (SE terminus)} \tag{13}$$

These direct SU-driven components account for the largest single contribution to the observed block rotation. The remaining ≈16°(CDF/Africa + Český Kráter + Bramsche) contribute additional chord displacements of ≈24 km (G5 N) and ≈25 km (G6 S), completing the total ≈52/54 km observed displacements.

12.3 Northward and Southward Terminus Displacement as a Function of Rotation Angle

For a dextral (clockwise) rotation of angle θ about P, the NW terminus (due west of P) sweeps northward and the SE terminus (due east of P) sweeps southward by approximately equal chord distances:

$$\Delta s \approx 2\,r\,\sin\!\left(\frac{\theta}{2}\right) \tag{14}$$

Table 11: Chord displacements of the NW (G5) and SE (G6) termini of the Sudete-Mons block for representative rotation angles about the Waltershausen pivot ($r_{G5} \approx 86$ km, $r_{G6} \approx 90$ km). G5 sweeps northward; G6 sweeps southward.

θ (dextral)	G5 displacement (km N)	G6 displacement (km S)	Notes
20°	29	31	insufficient
25°	37	38	insufficient
30°	44	46	lower bound
35°	**52**	**54**	**matches observed: G5 ≈48–52 km N; G6 ≈54 km S**
39°	57	60	upper bound

Self-consistency of the rotation model

For $\theta = 35°$:

- **G5 predicted post-position:** 9°33′E / 51°20′N (NW end sweeps northward). Modern identification: 9°35′E / 51°14′N. Residual after rotation correction: ≈ **11** km (within identification uncertainty of ±15–50 km for mountain block endpoints).
- **G6 predicted post-position:** 11°32′E / 50°22′N (SE end sweeps southward). Modern identification: 11°32′E / 50°22′N. Residual after rotation correction: ≈ **0.1** km (essentially perfect).
- **Block strike change:** from ≈ 90° (E–W) to ≈ 125° (ESE), a change of +35° dextral.
- **Inter-endpoint distance:** pre-rotation ≈177 km; post-rotation ≈168 km; difference ≈9 km (<6 %) rigid body within uncertainty.

12.3.1 The Rotation Pivot as Central Block Hinge: Waltershausen

Geometric principle: G5 and G6 as coupled termini of a single rigid block

The Ptolemaic Sudete Mons is a single mechanically coherent block extending from the NW terminus G5 to the SE terminus G6. Both endpoints are kinematically coupled: they belong to the same rotating body, and any displacement of one is inseparable from that of the other. The rotation pivot must therefore be derived from the **observed motion of the entire block**, not from either endpoint in isolation.

Derivation of the pivot from observed block motion. The NW terminus of the Thüringer Wald block (G5) occupied its pre-deformation position in the **Neukirchen area** (≈ 9°19′E / 50°53′N, ≈ 30 km west of Bad Hersfeld), approximately due west of

the Thuringian Forest's present structural front. After the deformation episode, this terminus is located at what the cartometric model identifies as the modern Kassel area (≈ 9°35′E / 51°14′N; the modern position of the G5 identification). This represents a displacement of ≈ 50 km largely northward (with a minor eastward component).

The SE terminus G6 (Lobenstein / Thüringer Schiefergebirge, 11°32′E / 50°22′N) moved in the *opposite* direction: southward, approaching the Danubius Fluvius (modern Main). Both endpoints thus constitute a system that **rotated dextrally**, with the western end sweeping northward and the eastern end sweeping southward.

For a rigid dextral rotation of $\theta \approx 35°$ mapping the NW terminus from its Neukirchen pre-position (9°19′E / 50°53′N) to its modern cartometric position (9°35′E / 51°14′N), the pivot P lies on the perpendicular bisector of the endpoint displacement chord at distance:

$$r = \frac{d}{2\sin(\theta/2)} = \frac{\approx 49\,\text{km}}{2\sin(17.5°)} = \frac{49}{0.602} \approx 81\,\text{km} \tag{15}$$

from the chord midpoint. The perpendicular bisector intersects in two candidate points; the geologically consistent solution (within the Thuringian Forest block, not in the North Sea) is:

Geometric rotation pivot of the Sudete-Mons block

$$\boxed{P \approx 10°33'\,\text{E} \,/\, 50°53'\,\text{N}} \tag{16}$$

Located approximately **2 km south-west of Waltershausen** and ≈ 20 km south-east of Eisenach; in the **north-western structural front zone of the Thüringer Wald**, where the Variscan crystalline basement descends northward into the Triassic Thuringian Basin. The pivot is the *natural structural hinge* of the crystalline block.

Pivot as the geometric centre of the block. The pivot at Waltershausen lies essentially *at the mid-longitude* of the pre-deformation block:

Table 12: Lever arms and displacement predictions for the Waltershausen pivot ($P \approx 10.542°$ E / $50.882°$ N) under a 35° dextral rotation. Both endpoints move by nearly equal distances in opposite directions (north and south respectively), consistent with a central-hinge rigid rotation.

Quantity	G5 (NW terminus)	G6 (SE terminus)	Assessment
Pre-rotation position	9°19′E / 50°53′N	11°49′E / 50°49′N	Both ≈ 50°51′N: E–W block
Lever arm from P	≈ 86 km (due W)	≈ 90 km (nearly due E)	Block centre at P
Chord displacement $2r\sin(\theta/2)$	≈ 52 km NNW	≈ 54 km SSE	Equal and opposite
Post-rotation predicted	9°33′E / 51°20′N	11°32′E / 50°22′N	—
Modern identification	9°35′E / 51°14′N	11°32′E / 50°22′N	—
Residual after rotation	≈ 11 km	≈ 0.1 km	Within uncertainty
$d(P$, Stolberg)	≈ 83 km		Inside SU outer ring — pivot on southern rim

The ≈ 11 km residual at G5 arises from using the approximate Neukirchen identification; the rotation-consistent G5 pre-position is at ≈ 9°26′E / 50°49′N (≈ 10 km from Neukirchen and at the same latitude as G6's pre-position), within the identification uncertainty of ±15–50 km for mountain block endpoints.

Physical interpretation. The Waltershausen hinge is located at the NW structural front of the Thuringian Forest crystalline basement — the boundary where the rigid Variscan metamorphic rocks give way to the weaker Triassic Thuringian Basin sediments. This is a natural mechanical discontinuity at which the block is free to rotate:

- **At** P (Waltershausen): the crystalline basement is exposed at the surface; the block is anchored here by its own rigidity and the adjacent sedimentary basin resistance.
- **NW terminus G5** (≈86 km from P, due west): the western Thüringer Wald descending toward the Hessian Basin — the mechanically weaker flank, displaced ≈52 km northward by biaxial extrusion and the Saale-Unstrut impact loading.
- **SE terminus G6** (≈90 km from P, nearly due east): the Thüringer Schiefergebirge adjacent to the Bohemian crystalline province — displaced ≈54 km southward, approaching the Danubius Fluvius (Main).

The pivot at ≈83 km from the Stolberg outer-ring centre (Saale-Unstrut) lies *on the southern outer rim* of the postulated impact structure (§11). The Thuringian Forest block rotated as a rigid lid about this rim boundary, with the NW end deflecting northward and the SE end falling southward toward the Danubius.

12.3.2 NW-Flank Dual Geometric Alignment

This *dual geometric alignment* of G5 is mechanically significant: it places the NW terminus of the block in the zone of maximum deformation forcing — at the outer rim of the SU impact field and within the biaxial stress corridor. The rotation pivot at Waltershausen (≈83 km from Stolberg, on the southern outer rim) separates the directly impacted outer-rim zone (which includes G5's pre-event position at Neukirchen) from the near-intact far-field to the east (the Bohemian-rooted SE terminus G6). The block rotated about this rim boundary as a lid rotating about its own near-centre.

12.4 G7 (Sarmate Mons N): Biaxial Lateral Extrusion

Revised G7 kinematic model (v6: biaxial NE lateral extrusion)

In v5, G7 (Lusatian Highlands) was interpreted as "T-G + Backstop-collision overthrust." In v6, a geometrically more parsimonious model is adopted based on the following analysis.

Under $c = 15.2\,\mathrm{km}/^{\circ}_{P}$, the bias-corrected G7 displacement vector is: $\Delta E = +93.9$ km, $\Delta N = +70.6$ km, magnitude = 117.5 km, azimuth = 53.0° (NNE).

The biaxial SU–CK compression axis has azimuth ≈ 134.4° (Geiseltal → Tábor); the perpendicular extrusion direction is $134.4 - 90 = 44.4°$ (NNE). The observed displacement azimuth (53.0°) deviates only 8.6° from the expected extrusion perpendicular (44.4°) — within the combined geometric uncertainty of ±10–15°.

Critically, the pre-deformation position of G7 lies only 5.2 km perpendicular to the SU–CK axis — *essentially on the axis.* A body on the compression axis experiences *maximum* lateral extrusion force in the perpendicular direction. This geometric arrangement is non-coincidental: it makes G7 the maximally exposed element to the biaxial field.

Kinematic decomposition of G7:

- $\Delta E = +93.9$ km: décollement-coupled, identical to the Elster Cluster ENE translation (same Zechstein décollement, same directional filter).
- $\Delta N = +70.6$ km: biaxial NNE lateral extrusion perpendicular to the SU–CK compression axis; ≈55% SU-driven, ≈45% CK-driven.

This model is *more parsimonious* than the backstop-collision model: it requires no new mechanism, deriving directly from the biaxial stress field already established in the model.

Under $c = 15.2\,\mathrm{km}/^{\circ}_{P}$: $\Delta E = +93.9\,\mathrm{km}$, $\Delta N = +70.6\,\mathrm{km}$; azimuth 53.0° vs. expected 44.4° ($\Delta\theta = 8.6°$, within ±10–15°). Pre-deformation G7 position only $d_{\perp} = 5.2\,\mathrm{km}$ from the SU–CK compression axis.

12.5 The Thüringer Wald as a Centrally Pivoted Rotation Structure

The kinematic picture that emerges is:

- **Before the deformation:** The Thüringer Wald block ran E–W at ≈ 50°51′N, from the Neukirchen area (9°19′E) in the west to ≈ 11°49′E in the east — parallel to the Danubius Fluvius (Ptolemaic $\phi_P \approx 48.5°$). The structural hinge at Waltershausen (10°33′E) lay near the longitudinal centre of the block.
- **During the impact episode (≈525–531 AD):** The Saale-Unstrut impact's down-range (WNW → ESE) compression, combined with the biaxial Bramsche–Geiseltal stress field, loaded the NW terminus (G5, ≈86 km from the hinge on the SU outer-rim boundary) northward. The pivot at Waltershausen served as the structural resistance point.
- **Result:** A dextral (+35° clockwise) rigid-body rotation of the entire Thüringer Wald block about its near-centre at Waltershausen. The NW terminus swept ≈52 km northward; the SE terminus swept ≈54 km southward, closing the distance to the Danubius Fluvius (Main) from ≈110–120 km (pre-event) to ≈30–40 km (post-event).
- **The Thüringer Schiefergebirge** (ductile envelope adjacent to the rigid crystalline core near G6) absorbed differential motion through internal shearing and SW–NE transversal foliation, discordant to the pre-rotation bulk W–E strike.

13. Three Parallel Force Vectors and the Geodynamic Chain Reaction

The deformation field of *Germania Magna* cannot be attributed to a single trigger. Three approximately concurrent force vector systems acted on a lithosphere that was already pre-loaded by Africa–Europe convergence (Nielsen et al., 2007). Each vector targets a different primary observable, but all three superpose on the same regional stress background and together produce the cartometric residuals documented in Part II.

13.1 Vector A: CDF Reactivation and the Africa Impactor Hypothesis

The Caledonian Deformation Front (CDF) and the broader Trans-European Suture Zone (TESZ) are reactivatable structures demonstrated by deep-seismic and potential-field data (Lyngsie & Thybo, 2007; Deutschmann et al., 2018). The trigger for the 6th-century reactivation is hypothesised to be a separate cosmic impact on the southern

African continental plate (Allan & Delair, 1997). Such an impact would have generated an impulsive acceleration of Africa–Europe convergence, with a plate-wide elastic stress pulse propagating to Europe via the Nielsen mechanism. For the transmission of stress from a source over distance r to the CDF, an exponential attenuation law applies:

$$\sigma_{\mathrm{CDF}} = \sigma_0 \cdot \exp\left(-\frac{r}{L_e}\right) \tag{17}$$

where $L_e \approx 700$–1000 km is the elastic relaxation length of the European plate. The reactivated CDF then drives lateral extrusion of Cimbrian-Peninsula sediments southward and eastward, producing the regional NNW-directed background stress that loads the Elster-Cluster sediment cover for its eastward glide.

Primary observable for Vector A: contributes ∼10 % to the Elster-Cluster eastward translation; contributes ∼15 % to the Sudete rotation (through regional stress coupling).

13.2 Vector B: Český Kráter Impact — SE-Compression and Westward Compression

The Český Kráter impact at Tábor (Section 45) generated a shock field whose principal projections are:

1. **SE-directed compression toward the Elbe-Elster region:** contributes to the down-range pre-stressing of the Elster-Cluster cover and overlaps the Saale-Unstrut down-range lobe in the Elbe-Lineament corridor. This vector explains why Herzberg and Doberlug-Kirchhain experienced superposed stress from *two* approximately synchronous impactors — a coincidence that is dynamically coherent given the GISP2 four-horizon record (Abbott et al., 2014).

2. **Westward compression toward the Main valley** (Maindreieck/Mainviereck): from the Český Kráter centre at Tábor (14.67° E / 49.42° N), the Maindreieck (Spessart, ≈9.5° E / 50.0° N) lies at azimuth ≈ 285° (WNW) at ≈ 390 km. The Main-valley floor receives compressive loading from this direction. See §15 for the buckling kinematics.

Primary observable for Vector B: contributes ∼35 % to the Elster-Cluster eastward translation (SE-compression component); contributes ∼15 % to the Sudete rotation (secondary coupling, primarily through the Elbe-Zone) ; dominates the Main-valley buckling.

13.3 Vector C: Saale-Unstrut Fragment Impact — Primary Local Driver of the Sudete Rotation

The Saale-Unstrut Fragment Impact (§11) generated a shock field with a WNW → ESE deformation vector. Its principal projections are:

1. **Southward rim displacement of the Thüringer Wald:** ≈50–60 km of southward shift at the eastern terminus, corresponding to $\theta_{SU} \approx 18°$–$22°$ of clockwise rotation about the Kassel-area pivot.

2. **Eastward deformation toward Erzgebirgsvorland, Chemnitzer Caldera, Lausitz, Markgrafschaft Meißen, and Elbe-Elster region**: down-range ejecta and structural overthrust, contributing to the Elster eastward translation.

3. **Sediment overthrusting at Herzberg / Doberlug-Kirchhain**: the down-range distal lobe may have overthrust pre-existing Viséan coal-bearing sequences, contributing to the structural-overprint and rank-elevation signature documented at Doberlug-Kirchhain (§31).

Primary observable for Vector C: contributes ∼50 % to the Elster-Cluster eastward translation; contributes ∼55 % to the Sudete rotation (*primary local driver*).

13.4 Vector D: Bramsche Pluton — Passive Structural Endpoint

The Bramsche pluton (8.00° E / 52.42° N) is a passive endpoint, not an active forcing. It defines the NNW boundary against which the southward-propagating CDF pulse is resisted, channelling the regional compression into the Bramsche–Saale–Tábor structural corridor.

Primary observable for Vector D: contributes ∼5 % to the Elster-Cluster translation (geometric focusing) and ∼10 % to the Sudete rotation (inherited structural anisotropy).

14. Quantitative Trigger Budget (revised v7)

Table 13: Quantitative trigger budget (v7 revision). Percentages are attribution weights, not energy measurements. Uncertainties ±15 percentage points. **Major revision**: Africa/CDF reduced from 40 % to 10 % for Elster translation; SU raised from 20 % to 50 %; CK raised from 25 % to 35 %; Bramsche reduced from 15 % to 5 %.

Vector	Elster (−93 km)	Sudete (+35°)	Rationale (v7)
A. Africa impactor / CDF	**10 %** (was 40 %)	**15 %** (was 20 %)	Primarily a pre-loading mechanism (CDF reactivation near Coulomb threshold) and source of the SSE directional component (−16.1 km, $p \approx 0.035$); not a direct translation driver
B. Český Kráter	**35 %** (was 25 %)	**20 %**	SE compression toward Elbe-Elster channelled via Elbe Lineament; Zechstein décollement directional filtering
C. Saale-Unstrut Fragment	**50 %** (was 20 %)	**55 %**	**Primary driver**: Elster Cluster lies directly in SU ESE down-range lobe (r = 40–90 km from SU inner centre); energy comparable to translation work
D. Bramsche (passive endpoint)	**5 %** (was 15 %)	**10 %**	Geometric channelling along Bramsche–SU–CK corridor; inherited anisotropy
Sum	**100 %**	**100 %**	

Justification of the revision

The v6 budget gave Africa/CDF 40 % of the Elster translation despite the only directly quantifiable Africa signal being the SSE component (∼−16.1 km, i.e. ∼17 % of total Elster magnitude). The remaining 23 percentage points were attribution-by-narrative, not calculation. Under v7: Africa/CDF is restricted to its directly quantifiable contribution (∼10 %); SU is restored to ∼50 %, consistent with its dominant energy contribution and direct geometric coupling. Total energy budget ($E_{\mathrm{SU}} + E_{\mathrm{CK}} \approx 6 \times 10^{21}$ J) remains compatible with the estimated translation work $W_{\mathrm{tr}} \approx 6 \times 10^{21}$ J without invoking large Africa/CDF energy transmission.

15. Main-Valley Buckling: Geometric Corollary of the Český-Kráter Shock Wave

The hypothesis that the modern Main is identical to Ptolemy's *Danubius Fluvius* (Section 6; cf. Mildner 2025/2026) requires a mechanical explanation for the strikingly

meandering character of the modern Main course between Bamberg and Mainz — in particular the orthogonal "Maindreieck" (around the Spessart) and "Mainviereck" (around the Fränkische Platte) inflection points.

15.1 Geometric Coincidence with the Force Field

The Maindreieck/Mainviereck zone lies at approximately $\lambda = 9.5°$–$11.0°$ E, $\phi = 49.7°$–$50.2°$ N — precisely south of the rotating Sudete-Mons block and approximately along the projected WNW shock-wave trajectory from the Český Kráter toward the Taunus/Hessen area:

Table 14: Geometric parameters of the postulated compressive loading of the Main-Talboden under the WNW-directed shock from the Český Kráter system.

Feature	Position	Distance to Český Kráter centre
Sudete-Mons E endpoint (post-shift)	11.53°E / 50.37°N	240 km
Maindreieck centre (Spessart)	9.5°E / 50.0°N	390 km
Mainviereck centre (Fränkische Platte)	10.5°E / 50.0°N	320 km
Shock-wave bearing from CK	WNW	—
Wavefront orientation at Main	N–S to NNE–SSW	—

15.2 Mechanical Interpretation

The same WNW-directed compressive vector that contributes to the Sudete-Mons rotation (via Elbe-Zone coupling, Vector B of §13) also encountered the (originally roughly straight) Main-Talboden further south as a transverse N–S oriented soft target. Under the resulting compressive loading, an originally near-linear west-flowing river valley floor is mechanically predisposed to buckle into a sequence of near-orthogonal alternating bends (kink folds) at wavelengths set by the relevant flexural rigidity of the upper-crustal column. The observed pattern — two orthogonal triangular and quadrangular bends with approximately 80–100 km wavelength — is geometrically consistent with such a kink-fold response.

Working hypothesis (geometrically suggested, not proven)

The Maindreieck and Mainviereck are interpreted in this model as the surface expression of compressive kink-folding of the Main-Talboden under the WNW-directed shock wave from the Český Kráter system. This hypothesis provides a single mechanical event family that simultaneously contributes to both the Sudete-Mons rotation (via the Elbe-Zone coupling) and the Main-valley geometry — a parsimony that is itself a methodological argument in favour of the integrated framework. The proposal is explicitly offered as a falsifiable working hypothesis; quantitative finite-element modelling of the kink-fold response remains to be carried out.

The Maindreieck/Mainviereck interpretation has an important chronological consequence: if the kinks represent a single catastrophic deformation episode rather than the millennial-scale meandering of a normal river, then the fluvial geometry of the modern Main must postdate the 6th century AD. Sediment cores from the kinks (especially the Spessart bend) should preserve a stratigraphic discontinuity at the corresponding horizon (falsification test T7, §57).

The identification of the modern Main as the Ptolemaic *Danubius Fluvius* requires a mechanical explanation for the Maindreieck and Mainviereck inflection points. The WNW-directed compressive vector from Český Kráter encountered the originally roughly straight Main-Talboden as a transverse N–S oriented soft target. Under the resulting compressive loading, the Main-valley floor buckled into a sequence of near-orthogonal alternating bends (kink folds) at wavelengths set by the relevant flexural rigidity of the upper-crustal column.

Coherence with the Danubius anchor (v6)

The Maindreieck/Mainviereck buckling interpretation and the Danubius-as-southern-anchor interpretation are *mutually consistent*: the pre-buckling Main course would have been roughly parallel to the Sudete Mons (both W–E), as implied by the Ptolemaic parallel latitudes. Post-buckling, the kinked Main course no longer provides a clean W–E reference. This is precisely why the model restricts the K4 Danubius anchor to the **western, pre-kink segment** (Taunus/Höchst area) and explicitly excludes the Maindreieck/Mainviereck zone from calibration use.

15.3 V7 Update: Timing Relative to the Unified Abnobae Rotation

The Main-valley buckling (Maindreieck/Mainviereck) and the sinistral rotation of the unified southern Abnobae block are distinct but related kinematic events:

1. The HTBF-driven sinistral rotation of the southern Abnobae block ($\sim -22°$ CCW)

deflected the Mud/Mümling drainage from the proto-Rhenus to the Main (river capture; §53).

2. The CK-induced WNW-directed shock wave then buckled the (now Main-routed) river into the Maindreieck/Mainviereck pattern.

3. **Sequence:** HTBF rotation precedes or accompanies CK buckling; both are part of the same 525–531 AD deformation episode.

16. Impact-Triggered Fracturing, Secondary Volcanism, and Hydrothermal Activity

The regional clustering of Central European kaolin deposits is strikingly non-random and follows tectonic depressions, grabens, and fault zones within and around the Bohemian Massif, as Jasmund & Lagaly (1993) illustrate. Major concentrations occur in western/central Bohemia (Karlovy Vary granites, Plzeň/Podborřany arkoses), extending northward into Saxony (Kemmlitz district, Meissen area, Lusatia/Lausitz) and adjacent zones along the Ore Mountains (Erzgebirge/Krušné hory) deformation front.

Under this model, the Český Kráter's radial and concentric fractures served as long-lived conduits for magma ascent and CO_2-rich hydrothermal fluids, even hundreds of kilometres from the centre. These deep-seated weaknesses reactivated the Central German Fault Zone (CDF) and segments of the TESZ, channelling both Permian secondary volcanism and prolonged Cretaceous–Tertiary fluid circulation.

16.1 Permian Volcanic-Hydrothermal Precursor

Seyhan (1971) establishes the primary petrogenetic framework: kaolinisation is predominantly magmatic-hydrothermal, beginning during volcanic and magmatic activity itself through rapid pH fluctuations in acidic thermal solutions. Götze et al. (2024) provide direct evidence from the NW-Saxonian Basin (Kemmlitz rhyolite, ≈290 Ma): fluid-inclusion data indicate agate formation above 150°C, with silica mobilisation starting during the late volcanic stage. Trace-element signatures include high boron (29 ppm), germanium (>18 ppm), and uranium (>19 ppm) — evidence of intense fluid-rock interaction involving magmatic volatiles.

16.2 Tertiary Reworking and Economic Deposits

Schmitz (2008) documents the Tertiary reworking of this system into economic kaolinitic clay deposits in the same regions — Lusatia (Oberlausitz: Caminau and Wiesa granodiorite-kaolins) and the Geiseltal near Halle (Spergau Buntsandstein-kaolin and Roßbach clays). These clays are the fine-grained terrestrial relocated products of a thick Upper Cretaceous–Tertiary kaolinitic weathering crust developed on basement rocks. The statistical spatial analysis of this clustering (binomial distance test, $p \approx 3.4 \times 10^{-5}$ at

$r = 270$ km) is presented in Section 30.

16.3 Shock Minerals as Structural Tracers

Shock minerals provide the "smoking gun" for the Český-Kráter impact; their spatial alignment along the rectified grid (≈28 km per degree) confirms the physical relevance of the reconstruction and explains why kaolinisation intensity peaks where fracture density is highest.

17. The Geodynamic Chain-Reaction Model

17.1 Lithospheric Weaknesses and Tectonic Reactivation

The geodynamic model is underpinned by deep seismic and potential-field data, which confirm that the Caledonian Deformation Front (CDF) and the Trans-European Suture Zone (TESZ) served as long-lived lithospheric weaknesses, repeatedly reactivated by subsequent stress fields. Along the MONA LISA profile 3, Lyngsie & Thybo (2007) demonstrate clear crustal differentiation: Avalonia crust ($\rho \approx 2715\ \mathrm{kg\,m^{-3}}$) was obliquely thrust over the lower Baltica crust ($\rho \approx 2775\ \mathrm{kg\,m^{-3}}$) in a ramp–flat–ramp geometry spanning roughly 150 km.

Nielsen et al. (2007) link mid-Palaeocene North Atlantic rifting (≈62 Ma) to the later reactivation of the CDF/TESZ under renewed compression. Using an elastic spherical shell model ($E = 70$ GPa, $\nu = 0.25$, $T_e \approx 7$ km), they calculated the compressive force of Africa–Europe convergence as $\sigma_{\text{Africa-Europe}} \approx 3\text{–}4 \times 10^{12}\ \mathrm{N\,m^{-1}}$.

For a stress source at $r \approx 450$ km from the CDF main trace (e.g., a Český Kráter source), the exponential attenuation law gives:

$$\frac{\sigma_{\text{CDF}}}{\sigma_0} = \exp\!\left(-\frac{450}{850}\right) \approx 0.59 \tag{18}$$

i.e. ≈59 % of the source stress reaches the CDF — sufficient for tectonic reactivation if σ_0 reaches a significant impulsive level. For the Saale-Unstrut source at ≈280 km, the transmitted stress is insufficient for direct CDF reactivation by that fragment alone (§41), motivating the multi-fragment + Africa-impactor framework of §14.

17.2 The North Sea Central Graben as Compressional Syncline

While classical geology views the North Sea Central Graben as an ancient, purely extensional rift system, extreme NNE–SSW compressional forces are postulated to have caused sudden folding of the crust. In this scenario, the Central Graben acted as a syncline or marine foreland basin violently compressed and forced downward by orogenic folding to the north. This abrupt tectonic reactivation generated immense geological instability, acting as a massive shock that caused gigantic sediment masses to collapse — an event analogous to the Storegga Slide.

Arfai et al. (2018) confirm an anomalous Quaternary subsidence pattern in the northwestern German North Sea, with subsidence rates reaching 480 m/Ma. The residual unexplained subsidence of ≈180 m (≈17 %) is reinterpreted as the elastic crustal depression from compressional over-deepening. The volumetric estimate of tsunami sediment as a northward coastal migration driver ($V_{\text{required}} \approx 360$ km$^3 \approx 12.9\,\%$ of the Storegga slide volume) is detailed in Section 34.

17.3 The Biaxial Bramsche–Český Kráter Stress Field

The Bramsche pluton (8.00° E / 52.42° N), the Geiseltal impact centre (11.73° E / 51.33° N), and the Český Kráter centre near Tábor (14.67° E / 49.42° N) define a structural corridor at approximate azimuth ≈120°/300°with a total length of ≈530 km. The biaxial loading between the boundary forces pre-loads the system to within 5 MPa of the Coulomb failure threshold for pre-saturated Triassic sediments (Mildner, 2025/2026, Part 4, § 5). Under this pre-loading, the Saale-Unstrut impact acts as both a **primary local driver** (for the Sudete rotation) and an **amplification step** (for the Elster glide) in a lithosphere already near failure — a physically far more economical model than a purely single-impact-driven displacement.

17.4 The Lausitz Block as Rigid Backstop

The Lausitz Block (Lusatian Granodiorite, Neoproterozoic–Cambrian, 505–520 Ma) functions as a **rigid tectonic backstop** (revised v5 terminology) against which the eastward-gliding Elster-Cluster sediment cover is arrested. In v1–v4 this block was sometimes described as a "rotation pivot," but the pivot-distance test of §8.2 demonstrates that this is geometrically incompatible with the observed $\overline{\Delta d} = -88$ km collapse of the Elster-Cluster distance to Senftenberg. The correct mechanical description is *translation toward a rigid backstop*, with the Lausitz block defining the eastern terminus of the glide rather than the centre of a rotation.

17.5 The Storegga Slide and Doggerland

The Storegga Slide tsunami (Weninger et al., 2008) involved 2,400–3,200 km^3 of material, with run-up heights of 10–12 m on the Norwegian coast and ≈3 m in the southern North Sea. In the revised chronology presented here, the geodynamically triggered analogue of this event was not a prehistoric Stone Age phenomenon but a much more recent geodynamic chain reaction directly responsible for reshaping modern European coastal topography. A Mercator map (*Nova et aucta orbis terrae descriptio*, 1569) records a landmass in the *Oceanus Germanicus* as *Albionis Pars* ("Part of Britain"), which is read here as a transmission witness of a still-extant shallow shelf area captured in the ancient cartographic source tradition. Both the chronological conflict and the falsifiability criteria are addressed in Section 33.

17.6 V7 Update: Erzgebirge Ore Deposits as an Interference Grid (new)

Mechanical-geometric interference grid in the Erzgebirge

The NE-SW orientation of the Erzgebirge reflects the fabric of the crystalline basement. The present model examines the mathematical-geometric *interference pattern*: while the active stress corridor of the impact field runs NW-SE (Bramsche→SU→CK), these forces impinge — either perpendicularly or at an angle — upon the pre-existing NE-SW Variscan fabric. The ore deposits concentrate precisely at the points (and thus between the two impact centres) where the NW-SE shockwaves intersected the NE-SW structural framework. This explains the concentration of mechanical energy responsible for the metamorphic overprinting; the deposits are aligned parallel to the main ridge of the Erzgebirge (NE-SW).

In this interpretation:

- The **Hercynian direction** (NW–SE) functions primarily as a conduit system through which shockwaves from the Saale-Unstrut and Bohemian impacts were coupled into the crust as directed stress vectors.
- The **Erzgebirge direction** (SW–NE) often acts as a blocking resistance or passive guiding element, absorbing stress peaks and processing them through secondary fragmentation.
- Ore deposit formation at intersection points results from this mechanical interaction: the older NE-SW structures were subjected to additional compression by the NW-SE stress vector, producing the specific overprinting that characterises the present-day structural fabric.

17.7 Methodological Robustness: Against Rubber-Sheeting

The reconstruction is strictly constrained by an unyielding matrix of fixed global scaling, hydrology, geological curvature, and verifiable geochemical anomalies. The model relies on Bayesian modelling, spatial point-pattern analysis (Ripley's K-function), and spatial autocorrelation (Moran's I test). Coordinate residuals are treated not as statistical noise, but as tectonically induced signals.

The model is rigidly constrained by four simultaneous, independent constraints that no arbitrary digital distortion algorithm can satisfy jointly:

(1) **Geometric scaling rigidity:** $k = 28$ km/° derived from the empirically measurable Rhine–Elbe baseline.

(2) **Hydrographic topological constraint:** The identified river system must have two major source branches travelling >50 % of their northward course south of a

specific mountain range, converging east of it — exactly fulfilled in the Lusatian Schwarze Elster/Spree system.

(3) **Cartographic curvature constraint:** The graphic bend of the *Asciburgius Mons* on the Germanus map must correspond to a geologically verified tectonic hinge zone.

(4) **Geochemical anchor:** *Budorigum* = Doberlug-Kirchhain falls on a stress-metamorphism and structural-overprint anomaly independently measurable from cartometry (see Section 24.2 and the revised mechanism in §31).

In v5, a fifth diagnostic constraint was added: the **kinematic-class consistency** of the residuals. Blocks identified as translation-glide must show pivot-distance collapse; blocks identified as rigid rotation must preserve pivot-distance within <5 %. The v5 gazetteer satisfies both of these consistency tests (Table 5).

18. Summary of Part I: Conclusions

1. **Cartometric foundation:** $\overline{\Delta\lambda} = -93.1\,\text{km}$ ($t = -13.7$, $p < 0.001$, $df = 3$; extended to $t = -19.1$, $df = 5$ with 6-point EC), incompatible with uniform measurement error.

2. **Kinematic taxonomy:** Translation-glide (Elster) and rigid-rotation (Sudete) blocks coexist; Lausitz as rigid backstop; Arsonion localises the décollement tip.

3. **SSE component:** Elster azimuth ≈ 100°; $-16.1\,\text{km}$ ($p \approx 0.035$); CDF NNW extrusion.

4. **Southern Danubius anchor:** G8 promoted to K4; $c = 15.2\,\text{km}/^{\circ}_{P}$; G6 $r_{\text{corr}} = 12.0\,\text{km}$.

5. **Sudete pivot:** Waltershausen (10°33′E / 50°53′N), universal for two counter-rotating blocks.

6. **G7 biaxial extrusion:** Azimuth 53° vs. expected 44°; $d_{\perp} = 5.2\,\text{km}$ geometrically non-coincidental.

7. **Revised trigger budget (v7):** SU 50 %, CK 35 %, Africa/CDF 10 %, Bramsche 5 %.

8. **Erzgebirge interference grid (v7):** NW-SE shock corridor intersects NE-SW basement fabric; deposits at intersection nodes.

9. **Vistula=Lausitz proportional cross-check (v7):** ≈325 km predicted; Oder

≈300 km (match); Weichsel ≈620 km (irreconcilable).

10. **Cimbrian peninsula re-identified (v7):** Lüneburg Heath promontory ending at Mecklenburg Bay margin — not Jutland.

11. **Historical convergence:** GISP2 horizons, dendroclimate, chronicles, and settlement hiatus converge on 525–540 AD.

Part II
Cartometric Foundations, Residual Analysis, Statistical Interpretation, and Bias-Corrected System

19. Introduction to the Cartometric Model

The currently paradigmatically influential reference model, the statistical-geodetic rectification of the TU Berlin group (Karlsen et al., 2011), explains deviations between Ptolemaic coordinates and modern topography primarily as measurement errors of ancient instruments or as transmission artefacts.

The model developed here opposes this concept. The primary explanatory principle is not the correction of errors in the ancient map itself, but the recognition that the northern reference line — the coastline of the *Oceanus Germanicus* — lay approximately 120 km further south during antiquity than today. Since medieval cartographers such as Donnus Nicolaus Germanus were unaware of this shift, they projected Ptolemaic coordinates onto an already geographically transformed landscape. The result was a systematic northward stretching of the map image, which inevitably produced a proportional eastward displacement of all eastern coordinates — thereby shifting the Ptolemaic *Vistula Fluvius* from its original Lusatian context all the way to the Polish Vistula. Geodynamic processes (reactivation of the CDF, lateral extrusion, multi-layer block kinematics) represent a secondary, here quantitatively investigated component.

20. The Cartometric Transformation Model

20.1 Scaling of the Ptolemaic Degree of Longitude

The core element of the rectification is an empirically determined, spatially fixed scaling factor k for the Ptolemaic degree of longitude. This is derived from the physical distance between the mouths of two invariant reference rivers — the Rhenus Fluvius (central mouth, $\lambda_P = 27.00°$) and the Albis Fluvius ($\lambda_P = 31.00°$), as well as the Vistula Fluvius ($\lambda_P = 45.00°$; identification: Oderberg, at the mouth of the reconstructed "United Vistula" into the *Oceanus Germanicus*).

The fitted transformation parameters are:

Fitted transformation parameters

$$\lambda_{\text{mod}} = -8.114 + 0.3989\,\lambda_P + 0.0770\,\phi_P$$
$$\phi_{\text{mod}} = +35.458 - 0.0167\,\lambda_P + 0.3244\,\phi_P$$

Longitude scaling: $k_\lambda = 27.0\,\text{km}/^\circ_P$. Latitude scaling: $k_\phi = 36.1\,\text{km}/^\circ_P$.

21. Residual Analysis of the Gazetteer (v7-updated)

21.1 Methodology

For all 22 non-calibration points in the gazetteer, the prediction residuals are calculated as:

$$\Delta\lambda = \hat{\lambda}_{\text{mod}} - \lambda_{\text{Mild}}, \qquad \Delta\phi = \hat{\phi}_{\text{mod}} - \phi_{\text{Mild}} \tag{19}$$

Conversion to ground kilometres at the mean latitude $\bar{\phi}$ of each point:

$$\Delta\lambda_{\text{km}} = \Delta\lambda \cdot 111.3 \cdot \cos\bar{\phi}, \qquad \Delta\phi_{\text{km}} = \Delta\phi \cdot 111.3 \tag{20}$$

The scalar total residual vector is the Euclidean norm:

$$r_i = \sqrt{\Delta\lambda_{\text{km},i}^2 + \Delta\phi_{\text{km},i}^2} \tag{21}$$

A negative $\Delta\lambda_{\text{km}}$ indicates that the transformed prediction lies west of the identified location, i.e., the identified location is further east than the linear model predicts.

Table 15: Residual analysis (v7-updated). Added: S-L Leukaristos (Finsterwalde), S-A Arsonion (Senftenberg zone, décollement tip), S-C Carrodunum (Spreetal/Nochten); F2 revised to Ottendorf-Okrilla; kinematic class updated. Cal. = Calibration Anchor; EC = Elster Cluster; EC-T = décollement transition.

No.	Name / Identification	$\Delta\lambda_{\text{km}}$	$\Delta\phi_{\text{km}}$	r [km]	Group	Class (v7)
K1	Rhenus Fl. – Hengelo/Enschede	0.0	0.0	**0.0**	Cal.	anchor
K2	Albis Fl. – NW Bremen	0.0	0.0	**0.0**	Cal.	anchor
K3	Vistula Fl. – Oderberg	0.0	0.0	**0.0**	Cal.	anchor
F1	Vistula main source – Königswartha	−61.5	+52.1	80.5	Lusatia	T-G
F2	**Vistula w. source – Ottendorf-Okrilla (v7)**	−124.0	+64.0	**142.0**	Lusatia	T-G

Table 15 (continued)

No.	Name / Identification	$\Delta\lambda_{\mathrm{km}}$	$\Delta\phi_{\mathrm{km}}$	r [km]	Group	Class
	(v6: Königsbrück/Pulsnitz, $r = 149.2\,km$) *bias-corr.: $r_{corr} = 127.2\,km$ (improved)*					
F3	Chalusus Fl. – Havelberg	−74.5	+21.0	77.4	Coast	T-G
F4	Suebus Fl. – Neuruppin	−63.4	+16.4	65.5	Coast	T-G
F5	Viadua Fl. – Finowfurt	−32.3	+7.1	33.1	Coast	T-G
S1	Agrippinensis – Cologne*	−6.9	+73.0	73.3	GB	—
S2	Aliso – Haltern am See*	−20.9	−1.8	21.0	GB	—
S3	Budorigum – Doberlug-Kirchhain	−87.1	+26.9	**91.2**	EC	T-G (SSE)
S4	Calisia – Calau	−38.2	+13.7	40.6	L-E	T-G
S-A	**Arsonion – Senftenberg zone (new v7)**	**−51.5**	+17.0	**54.2**	**EC-T**	**T-G (déc. tip)**
S5	Limis Lucus – Baruth/Mark	−78.2	+9.2	**78.7**	EC	T-G (SSE)
S6	Lugidunum – Falkenberg/Elster	−109.5	+24.5	**112.2**	EC	T-G (SSE)
S7	Stragona – Herzberg/Elster	−101.0	+11.8	**101.7**	EC	T-G (SSE)
S-L	**Leukaristos – Finsterwalde (new v7)**	**−87.4**	+23.7	**90.5**	**EC**	**T-G (SSE)**
S-C	**Carrodunum – Spreetal/Nochten (new v7)**	**−85.0**	+3.6	**85.1**	**EC**	**T-G (SSE)**
S8	Treva – Bremen	+26.6	−7.9	27.8	C-W	—
S9	Lirimiris – Bispingen/Soltau	−5.9	−24.6	25.3	C-W	—
G1	Ascib. Mons NW – E. Magdeburg	−46.5	+17.6	49.7	F	T-G+r
G2	Ascib. Mons SE – Calauer Schweiz	−31.3	+18.7	36.3	F	T-G+r
G3	Melibocus Mons W – Harz W	−23.3	−7.2	24.4	H	T-G+r
G4	Melibocus Mons E – Harz/Eisleben	−41.2	+39.1	55.2	H	T-G+r
G5	Sudete Mons W – TW NW / Kassel	−19.8	−13.7	23.9	T	R (NW endpt.)
G6	Sudete Mons E – Thur. Slate Mts.	+11.2	+71.6	72.5	T	R (rotated)

Table 15 (continued)

No.	Name / Identification	$\Delta\lambda_{\mathrm{km}}$	$\Delta\phi_{\mathrm{km}}$	r [km]	Group	Class
G7	Sarmate Mons N – Lusatian Highlands	−93.9	−2.2	94.0	L	T-G + biax.
G8/ K4	Abnobae Mons W – Taunus/Danubius	+11.2	+91.2	91.9	S	K4 anchor
G9	**Abnobae Mons E – Danubius source pre-def.**	—	—	—	**S**	**G9 (mobile; not anchor; pre-def. ≈ 8.96°E / 50.07°N)**
R0	**Rhenus source pre-deformation**	—	—	—	**S**	**K5 cand. (pre-def. ≈ 8.60°E / 50.06°N)**

* Gallia Belgica (different measurement system); latitude residuals evaluated separately.

22. Latitude Bias System and Bias-Corrected Residuals

22.1 The Two-Point Constraint System

The latitude bias system introduces two points (G7 and G8) as simultaneous constraints on the bias gradient c and the additional southward displacements of those blocks. With $s = 16.4\,\mathrm{km}$ (T-G SSE component), T_{G8} = tectonic northward shift of Taunus (≥ 0), and S_{G7} = additional southward shift of G7 beyond T-G SSE (≥ 0):

$$\text{G8:} \quad 91.2 = 6.0\,c + T_{G8} \tag{22}$$

$$\text{G7:} \quad -2.2 = 4.5\,c - s - S_{G7} \tag{23}$$

From Eq. 23: $c = (s - 2.2 + S_{G7})/4.5 = (14.2 + S_{G7})/4.5$

The physically allowed solutions $T_{G8} \geq 0$, $S_{G7} \geq 0$ give:

$$\boxed{3.16 \leq c \leq 15.2\ \mathrm{km}/^{\circ}_{P}} \tag{24}$$

Table 16: Bias-corrected residuals under $c = 15.2\,\mathrm{km}/^{\circ}_{P}$ (v7-updated). **F2 revised**: Ottendorf-Okrilla gives $r_{\mathrm{corr}} = 127.2\,\mathrm{km}$ (improved from Königsbrück 130.6 km). G6 confirmed at $r_{\mathrm{corr}} = 12.0\,\mathrm{km}$.

#	$\Delta\phi_{\mathrm{bias}}$ (km)	$\Delta\phi_{\mathrm{corr}}$ (km)	r_{corr} (km)	Δr (km)	Interpretation
K1–K3	0	0	0	0	Calibration anchors
K4/G8	−91.2	0.0	**11.2**	−80.7	Danubius anchor; bias absorbed
S3 Budorigum	−35.4	−8.5	87.5	−3.7	EC SSE signal
S5 Limis Lucus	−22.8	−13.6	79.4	+0.7	EC SSE signal
S6 Lugidunum	−38.0	−13.5	110.3	−1.9	EC SSE
S7 Stragona	−40.6	−28.8	105.0	+3.3	Strongest SSE
S-L Leukaristos	−23.8	0.0	**87.4**	—	EC; λ-dominant
S-C Carrodunum	−53.4	−49.8	**97.6**	—	EC; ϕ-bias-corr.
S-A Arsonion	−40.1	−23.1	**56.6**	—	Déc. transition; lower $\lvert\Delta\lambda\rvert$
F2 Ottendorf (v7)	−35.5	+28.5	**127.2**	−3.4	vs. v6 Königsbrück; Artesian spring; revised
G5 Sudete W	−76.0	−89.7	91.9	+68.0	Mobile NW terminus
G6 Sudete E	−76.0	−4.4	**12.0**	−60.5	Rotation confirmed
G7 Sarmate N	−68.4	−70.6	117.5	+23.5	Biaxial NE extrusion

23. Statistical Evaluation and Group Analysis (v7-updated)

23.1 Regional RMSE Analysis (v7)

From the residual magnitudes, the root mean square error (RMSE) is calculated for each homogeneous subgroup:

$$\mathrm{RMSE}_G = \sqrt{\frac{1}{n_G}\sum_{i\in G} r_i^2} \tag{25}$$

Table 17: Regional RMSE by point group (v7-updated). **Elster Cluster extended to $n = 6$; $\mathbf{RMSE_{obs}}$ decreases from 96.8 to 92.5 km.** New Arsonion group added as décollement-transition indicator.

Group	n	$\mathrm{RMSE_{obs}}$ (km)	$\mathrm{RMSE_{corr}}$ (km)	Mean $\Delta\lambda_{\mathrm{km}}$
Calibration (river mouths)	3	**0.0**	0.0	0.0
K4 Danubius anchor (G8)	1	91.9	**11.2**	+11.2
Elster Cluster core (S3,S5,S6,S7)	4	**96.8**	96.4	−94.0
Elster Cluster extended (+ S-L, S-C)	6	**92.5**	93.2	−91.4
Déc. transition (S-A Arsonion)	1	54.2	56.6	−51.5
Backstop-proximal (S4 Calisia)	1	40.6	41.8	−38.2
Coastal settlements W (S8, S9)	2	26.6	26.6	+10.4
Coastal rivers (F3–F5)	3	59.5	59.5	−56.7
Fläming (G1–G2)	2	43.0	42.0	−38.9
Harz (G3–G4)	2	42.7	46.3	−32.3
Sudete – G5 (NW endpoint)	1	23.9	91.9	−19.8
Sudete – G6 (rotated)	1	72.5	**12.0**	+11.2
Sarmate N (G7)	1	94.0	117.5	−93.9
Gallia Belgica (S1–S2)	2	47.2	43.1	−13.9
Vistula sources F1, F2 (v7)	2	**111.4**	**103.7**	−92.8

23.2 Extended t-Test: Elster Cluster ($n = 6$)

Table 18: Stepwise improvement of the t-test as new identifications are added to the Elster Cluster.

Version	n	$\overline{\Delta\lambda}$ (km)	s (km)	t	df
v6 (core EC)	4	−93.95	13.96	−13.7	3
+ Leukaristos (v7)	5	−92.64	12.45	−16.6	4
+ Carrodunum (v7)	**6**	**−91.37**	**11.57**	**−19.1**	**5**

For $df = 5$, $t_{\mathrm{crit}} = -6.87$ (at two-tailed, $\alpha = 0.001$):

$$\boxed{t = -19.1, \quad p \ll 0.001, \quad df = 5} \tag{26}$$

This confirms the translation-glide hypothesis at formally irrefutable significance. The Arsonion point ($\Delta\lambda = -51.5\,\mathrm{km}$) is deliberately *excluded* from the EC t-test since it represents the transition zone, not the uniformly displaced rigid block.

24. Geodynamic Interpretation of the Residual Patterns

24.1 The Elster-Cluster Translation-Glide (Reformulated in v5)

The highly significant eastward offset is consistent with the hypothesis of a regional, coherent translation-glide of the sedimentary cover. Reactivation of the Caledonian Deformation Front (Vector A of §13) generated a NNW-directed regional compression; lateral extrusion of sedimentary masses from the northwest (towards the Cimbrian Peninsula and the inner Barbaricum) advanced accretionary wedges against the western flank of the Fläming. The Saale-Unstrut Fragment Impact (Vector C) added a down-range deformation lobe that pushed the Elster-Cluster cover eastward along the Zechstein décollement. The Český Kráter impact (Vector B) contributed SE-directed compression along the Elbe-Lineament corridor. The Lausitzer Granodiorite Block in the southeast acted as a rigid backstop terminating the glide.

The result is a coherent eastward translation of ∼93 km of the Elster-Cluster sediment cover, with simultaneous ∼40 km translation of the deeper Fläming basement (Asciburgius Mons), giving the factor-2.4 cover/basement displacement ratio diagnostic of an actively-glided basal décollement (§9).

Geophysically, Deutschmann et al. (2018) document six polyphase reactivation episodes of the TESZ weakness zone from the Caledonian collision to Late Cretaceous inversion tectonics. Lyngsie & Thybo (2007) document a 150 km wide overthrust zone of Avalonian crust over the Baltica lower crustal shield — the deep-crustal geometry enabling such block displacement in geologically younger time.

24.2 Geochemical Verification: Anthracite at Budorigum

The residual of Budorigum (S3, $r = 91.2$ km) falls precisely at the postulated structural hinge zone. Near-surface anthracite deposits at Doberlug-Kirchhain — anomalous in their precise configuration — are interpreted in v5 as the result of *Saale-Unstrut down-range overthrust* acting on a pre-existing Viséan (Lower Carboniferous) coal-bearing sequence. The full reframed mechanism is presented in §31. The convergence of (a) the cartometric residual vector, (b) the down-range projection from the Saale-Unstrut impact, and (c) the Viséan protolith remains a methodologically powerful cross-validation that cannot be attributed to coincidence.

24.3 Ottendorf-Okrilla Artesian System: Physical Anchor for F2

Artesian spring system at Ottendorf-Okrilla: geological justification for F2 revision

The Ottendorf-Okrilla gravel-mining area (13.819°E / 51.201°N) is the **Typ-Lokalität** of the *Senftenberger Elbelauf* (Miozän–früh-Quartär): mächtige Kiessand-Sedimente a northward-flowing main palaeodrainage system, documented in active gravel-mining exposures. This is **not a Braunkohle (lignite) area**; the Kiessand-Abbaugebiet indicates the former fluvial corridor of the proto-Lausitz system. The Ptolemaic F2 source position corresponds to the ancient hydrological watershed between northward-flowing (proto-Vistula) and southward-flowing (Elbe) drainage, which remained morphologically legible in the landscape through antiquity.

Artesian confirmation: The *Albertplatz-Artesianbrunnen* in Dresden-Neustadt (drilled 1832–1836, depth 243 m, target horizon: Cenomanian sandstone, temperature **17.8°C**, **artesian overflow without pumping**) demonstrates that the same Cenomanian–Sandstein aquifer (sealed by Turonian Pläner as aquitard, trapped by the Lausitz Overthrust as structural closure) was under artesian pressure into the modern era. In antiquity this system would have produced continuous thermal spring discharge ($T \approx 15$–18°C, frost-free, wintertime-steaming) — a distinctive landmark recognisable to any ancient cartographer or informant.

Hydraulic geometry: $\Delta h = h_{\text{Erz.}} - h_{\text{Ottendorf}} \approx 600 - 210 = 390\,\text{m}$; $i = 390/65{,}000 \approx 0.006$ (sufficient for artesian overflow at Cenomanian permeability).

Bias-corrected residual: $r_{\text{corr}} = 127.2\,\text{km}$ (improved from Königsbrück 130.6 km).

25. Methodological Defence against Criticism (v7: seven constraints)

The v7 model is constrained by **seven simultaneous, independent constraints** ($F < 0$, overdetermined):

1. Geometric scaling rigidity ($k = 28\,\text{km}/^\circ$);
2. Hydrographic topological constraint (Lausitz river system; cross-validated by Harz–mouth proportional ratio, §6.4);
3. Cartographic curvature constraint (Fläming 'kink');
4. Geochemical anchor (Doberlug Viséan anthracite, §31);
5. Kinematic-class consistency (pivot-distance test);
6. North–South bias consistency (c must simultaneously explain G8 as Danubius anchor and confirm G6 as rotation prediction, $r_{\text{corr}} = 12\,\text{km}$);

7. [**NEW v7**] Universal-pivot consistency: the same Waltershausen pivot must simultaneously satisfy (a) the Sudete Mons rotation (+35° CW, $r = 86$–$90\,\mathrm{km}$ lever arms, sub-km residuals) and (b) the southern Abnobae rotation ($\sim -22°$ CCW, $r \approx 166\,\mathrm{km}$ lever arms, Rhenus/Danubius pre-deformation source identification consistent with Mercator 1569).

26. Summary of Part II: Conclusions

1. Scaling confirmed: $k = 27.0\,\mathrm{km}/^{\circ}_{P}$.

2. **Extended Elster Cluster**: $t = -19.1$, $p \ll 0.001$, $df = 5$. Irrefutable.

3. Arsonion localises the décollement tip (Coulomb-wedge structure confirmed).

4. Spatially autocorrelated structure: Coastal RMSE ≈27 km vs. Elster inland RMSE ≈92 km (6-point group).

5. Latitude bias $c = 15.2\,\mathrm{km}/^{\circ}_{P}$; G6 $r_{\mathrm{corr}} = 12.0\,\mathrm{km}$.

6. SSE component of Elster: $-16.1\,\mathrm{km}$ ($p \approx 0.035$).

7. F2 revised to Ottendorf-Okrilla: artesian spring system; $r_{\mathrm{corr}} = 127.2\,\mathrm{km}$.

8. Seven independent constraints confirm model robustness.

Part III
Extended Evidence Analysis: CDF Reactivation, Radial Kaolin Genesis, Anthracite Overprinting, and Tsunami-Driven Coastal Migration

27. Synthesis of Evidence Chains: The Necessity of an Integrated View

The statistically secured findings of Part II demand a geophysical explanation that goes beyond purely statistical coordinate analysis. Five key publications and one new geochemical reframing combine to provide methodologically heterogeneous but independently derived building blocks:

- Nielsen et al. (2007) for plate-stress transmission.
- Arfai et al. (2018) for anomalous Quaternary North Sea subsidence.
- Götze et al. (2024) for magmatic-hydrothermal kaolin genesis.
- Weninger et al. (2008) for the Storegga / Doggerland chronology.
- Kužvart (1992) for tectonic predisposition of Central European kaolin deposits.
- Geersen et al. (2024) for prehistoric RSL documentation.
- Viséan protolith of Doberlug-Kirchhain anthracite (Daber 1959; Paech 1989) — *new in v5.*

28. The Reactivatability of the CDF: Plate Stress Transmission

28.1 Core Finding of the Study

Nielsen et al. (2007) demonstrated, through high-resolution nannoplankton chronostratigraphy of the Sorgenfrei-Tornquist Zone (STZ), a direct causal link between mid-Palaeocene North Atlantic rifting (≈62 Ma) and an abrupt, plate-wide synchronous change in the intra-European stress regime. Using an elastic spherical shell model ($E = 70\,\mathrm{GPa}$, $\nu = 0.25$, $T_e \approx 7\,\mathrm{km}$), they calculated the compressive force of the Africa–Europe convergence as:

$$\sigma_{\text{Africa-Europe}} \approx 3{-}4 \times 10^{12}\ \mathrm{N\,m^{-1}} \tag{27}$$

The key conclusion for this model: *the European plate system can respond plate-wide and near-instantaneously to changes in plate boundary forces — without any thermal mantle plume being required.*

28.2 Relevance for CDF Reactivation

For the transmission of stress from a source over distance r to a target (CDF), an exponential attenuation law applies:

$$\sigma_{\mathrm{CDF}} = \sigma_0 \cdot \exp\left(-\frac{r}{L_e}\right) \tag{28}$$

where $L_e \approx 700{-}1000\,\mathrm{km}$. For $r \approx 450\,\mathrm{km}$ (Český Kráter to CDF main trace), $\approx$59 % of the source stress reaches the CDF.

Within the v5 framework, the necessary stress for CDF reactivation is not supplied by any single European impact alone but by the additional *Africa impactor* component (Vector A of §13), which produces the impulsive acceleration of Africa–Europe convergence required to overcome the elastic-shell attenuation. This is the hypothesis that connects the European observations to the global forcing budget.

29. Anomalous Quaternary Subsidence: Arfai et al. (2018)

29.1 Data Findings

Arfai et al. (2018) determined in the northwestern German North Sea sector a maximum Quaternary sediment thickness of **1,045 m** with subsidence rates up to **480 m/Ma** — a $> 10\times$ increase over Cenozoic averages. Load-induced subsidence via the Airy isostasy model:

$$y_{\mathrm{Airy}} = S^* \cdot \frac{\rho_s}{\rho_m} = 1045\,\mathrm{m} \cdot \frac{2080}{3270} \approx 665\,\mathrm{m} \tag{29}$$

Adding compaction of Neogene/Palaeogene strata (150−250 m):

$$y_{\mathrm{total}} = 665 + 200 = 865\,\mathrm{m} \tag{30}$$

The unexplained residual subsidence:

$$\Delta y_{\mathrm{Residual}} = 1045 - 865 = 180\,\mathrm{m} \quad (\approx 17\,\%) \tag{31}$$

Arfai et al. rule out renewed rifting, salt diapirism, and lithospheric buckling as explanations.

29.2 Reinterpretation

The North Sea Central Graben is postulated to represent not a classical extensional structure but a compressional syncline resulting from NNE-SSW directed folding — analogous to a foreland basin of an orogenic front to the north. The NNW-SSE orientation of the depocentre is consistent with a synclinal axis under NS compression, directly linking to Nielsen et al.'s (2007) flexural deepening framework. The 180 m residual subsidence would correspond to the elastic crustal depression from compressional over-deepening.

30. Radial Kaolin Genesis Around the Český Kráter

Revisions from v2/v3: revised crater rim definition, corrected binomial test, extended deposit inventory

1. The northwestern part of the outer crater rim of the Český Kráter is identified morphotectonically with the **Erzgebirge escarpment** at radius ≈ 130–150 km from the crater centre.
2. The relevant hydrothermal test boundary is the **farthest documented Rajlich ring** ($r \approx 270$ km), within which fluid pathways are confirmed.
3. The deposit inventory uses $n = 14$ kaolin sites.
4. A short section on the inter-impact corridor between Český Kráter and Saale-Unstrut is included.

30.1 Götze et al. (2024): Magmatic-Hydrothermal Genesis in NW-Saxony

Götze et al. (2024) demonstrate, from the Kemmlitz rhyolite (≈290 Ma, NW-Saxony), that agate-bearing lithophysae formed exclusively in a glassy pitchstone facies. Fluid-inclusion homogenisation temperatures document primary magmatic-hydrothermal silica mobilisation:

$$T_h^{\min} \in \{134\,^\circ\text{C (Gröppendorf)},\ 157\,^\circ\text{C (Börtewitz)},\ 177\,^\circ\text{C (Mügeln)}\} \tag{32}$$

Geochemical anomalies: B = 29 ppm, Ge > 18 ppm, U > 19 ppm. Chondrite-normalised REE patterns: $\frac{\text{Eu}}{\text{Eu}^*} = 0.004-0.16$, $\frac{\text{Ce}}{\text{Ce}^*} = 1.23-1.55$ — a classic hydrothermal formation profile. The Kemmlitz deposit lies ≈50 km north of the Erzgebirge escarpment (outer rim proxy), placing it in the proximal extra-crater zone of maximum ring-fracture hydrothermal permeability.

Kužvart (1992) documents that tectonic predisposition opens rocks to kaolinisation at depths reaching 80–113 m in tectonically stressed zones.

30.2 Distance Analysis: Three-Zone Model

Table 19: Structural zones of the Český Kráter used in the distance analysis.

Zone	Radius	Diameter	Character
Zone A: Inner crater	40–45 km	80–90 km	direct melt/breccia; UHP minerals
Zone B: Outer crater rim	130–150 km	250–300 km	= Erzgebirge escarpment; primary ring fractures
Zone C: Farthest Rajlich ring	≈270 km	≈540 km	outermost fluid conduit zone; kaolin clustering

Table 20: Distances of major Central European kaolin deposits from the Český Kráter centre and from the Erzgebirge escarpment (outer rim proxy). **Bold**: Zone A or B (within outer rim). *Italic*: Zone C (within farthest Rajlich ring, $r < 270$ km).

Deposit / Region	ϕ (°N)	λ (°E)	d centre (km)	d rim (km)	Zone
Plzeň Basin	49.75	13.40	**121**	inside	A/B
Znojmo	48.86	16.05	**105**	inside	A/B
Karlovy Vary	50.23	12.89	**184**	**30**	B
Podborřany / Kadáň	50.27	13.38	**167**	**25**	B
Ore Mts. N-margin ≈ rim	50.50	13.20	**196**	**≈0**	B
Schirnding / Hohenberg	50.08	12.23	*210*	**50**	C
Kreuzweiher	49.96	12.03	*218*	**60**	C
Hirschau / Schnaittenbach	49.53	11.96	*218*	70	C
Tirschenreuth	49.88	12.33	*210*	60	C
Kemmlitz / NW-Saxony	51.13	12.83	*271*	**50**	C
Lusatia / Caminau	51.38	14.23	*265*	**45**	C
Meissen-N (Ockrilla)	51.21	13.50	*240*	**40**	C
Meissen-S (Löthain)	51.14	13.40	*235*	**40**	C

30.3 Binomial Distance Analysis

Under the null hypothesis of uniform distribution within $R_{\max} = 450$ km, with $p_0 = (270/450)^2 = 0.360$ and $k = 13$ of $n = 14$ deposits within 270 km:

$$P(X \geq 13 \,|\, n = 14,\, p_0 = 0.360) \approx \mathbf{3.4 \times 10^{-5}} \tag{33}$$

Result: binomial test ($n = 14$)

At $r = 270\,\text{km}$, $k = 13$ of $n = 14$ major Central European kaolin deposits lie within the farthest Rajlich ring. The one-tailed binomial probability is $p \approx 3.4 \times 10^{-5}$ — highly significant ($p \ll 0.001$).

30.4 The Saale-Unstrut / Český Kráter Inter-Impact Corridor and Coal Deposits

The Lugau-Oelsnitz hard coal district lies ≈100 km SSE of the Saale-Unstrut outer ring boundary and within the outer crater rim zone of the Český Kráter (Zone B, $d \approx 212\,\text{km}$ from CK centre), in the Vogtland–Ore Mountains zone exactly between the two postulated impact structures. Together with the Freital/Döhlen Basin coal ($d \approx 240\,\text{km}$ from CK centre) and the Doberlug-Kirchhain anthracite (≈66 km east of the SU outer rim), these deposits define a spatially coherent belt running NW–SE between both impact structures. The interpretation is consistent with the observation that all three coal occurrences are anomalously shallow for their rank and are spatially co-located with kaolin deposits that independently indicate hydrothermal/fracture activity within the impact systems.

Integrated result: kaolin and coal spatial pattern

The spatial distribution of Central European kaolin and hard coal deposits defines a coherent radial pattern relative to the two postulated impact structures:

1. **Zone B/C kaolin** (40–70 km N of CK rim): Kemmlitz, Caminau, Meissen — hydrothermal fluid discharge through ring-fracture conduits.
2. **Inter-impact corridor coal** (Lugau-Oelsnitz, Freital, Oschatz): positioned between both outer rims, in the zone of maximum biaxial stress field overlap.
3. **Doberlug-Kirchhain anthracite** (≈66 km ENE of SU outer rim): interpreted in v5 as Viséan coal-bearing protolith subjected to Saale-Unstrut down-range overthrust / structural overprint (see §31).

31. The Doberlug-Kirchhain Anthracite Anomaly: v7 Pressure-Cooker Mechanism

In v1–v4 the near-surface anthracite at Doberlug-Kirchhain was described as the result of stress-metamorphic coalification driven by the geodynamic event. The v5 audit acknowledges that this formulation is geologically too strong: the Doberlug coal sequence is documented in deep boreholes as Viséan (Lower Carboniferous, Mittel-Visé floral assemblage; cf. Daber 1959; Paech 1989). The protolith is therefore ≈330 Ma old, not a 6th-century neoformation.

The refined v5 interpretation is therefore:

Reframed Doberlug-Kirchhain anthracite mechanism

The pre-existing Viséan coal-bearing sequence at Doberlug-Kirchhain (documented protolith age ≈330 Ma) was subjected to *structural-overprint, fracturing, exhumation, and possible thermal upgrading* by the down-range overthrust/ejecta lobe of the Saale-Unstrut Fragment Impact (≈66 km ENE of the outer ring). The impact did *not* create the coal; it modified pre-existing material in the way that explains the present anomalously shallow high-rank configuration. Specifically:

- Down-range overthrust sheets exhumed deeper coal-bearing strata closer to the surface than is typical for Carboniferous protoliths in tectonically quiet settings.
- Shock-wave fracturing locally elevated the coal rank by introducing additional mechanical/thermal energy (stress-metamorphic overprint).
- The structural setting — Doberlug at the Elster-Lusatia shear-zone boundary — is independently a high-strain zone that would amplify any overprinting effect.

This formulation respects both the documented protolith and the proposed Saale-Unstrut mechanism. It also generates a falsifiable prediction: deep core samples at Doberlug should show Viséan palynomorphs and floral assemblages at the deeper levels (the conventional Carboniferous record), with localised high-rank overprint signatures and impact-related fracturing restricted to a shallower zone (the down-range stress horizon). This is testable as falsification T7 (§57).

The geochemical/cartometric convergence noted in §24.2 (the residual vector for Budorigum and the petrographic anomaly at Doberlug-Kirchhain) is fully preserved by this v5 reframing; only the proposed mechanism is sharpened, not the empirical convergence.

Geological–mechanical description of the Doberluger Synklinorium pressure-cooker scenario

The sedimentary succession in the Doberluger Synklinorium occupies a narrow, deep synclinal depression where strata dip steeply (40°–60°) northeastward or southwestward, recording intense lateral compression. The coal seams occur in several thin groups that are intensely tectonised, fragmented into mutually displaced blocks, and discordantly overlain by younger Zechstein and Mesozoic strata (Göthel, 2014).

In the proposed model, the Fläming, immediately to the north, acts as the dominant rigid guide-rail structure — the surface expression of a deep-seated boundary along the Elbe Line. Together with the Lausitz Block to the south it forms a vise-like **geometric constriction**. Eastward translation of the Elster-Cluster crust into this funnel-shaped channel (with rigid lateral confinement on both sides) prevented any lateral escape, enforcing plane-strain shortening. The resulting kinematic boundary conditions produced high-angle folding and vertical extrusion, generating the observed 40°–60° dips and the synclinorium geometry itself.

At the eastern closure of the constriction, the 93 km displacement was abruptly arrested, converting translational kinetic energy into localised frictional heat within a **"pressure-cooker"** regime. Reactivation of the Central German Fault / Trans-European Suture Zone in the 6th century displaced older sequences, reconciling the apparent stratigraphic paradox while preserving the young thermal signature.

31.1 Quantitative Kinematics

Convergence half-angle of the Fläming–Lausitz constriction: $\alpha \approx 12°$. For incompressible plane-strain shortening:

$$\dot{\varepsilon}_{xx} + \dot{\varepsilon}_{yy} + \dot{\varepsilon}_{zz} = 0 \tag{34}$$

With $\dot{\varepsilon}_{yy} \approx 0$ (rigid walls) and $\dot{\varepsilon}_{xx} < 0$ (decelerating ENE flow), vertical extrusion is required: $\dot{\varepsilon}_{zz} = -\dot{\varepsilon}_{xx}$. Andersonian thrust-fault dip prediction with friction angle $\phi = 30°$:

$$\delta_{\text{thrust}} = 45° + \phi/2 = 60° \tag{35}$$

This is in exact agreement with the upper end of the observed 40°–60° dip range (Göthel, 2014).

31.2 Quantitative Thermodynamics: the Pressure-Cooker

The Zechstein evaporite cap is effectively impermeable ($k_{\text{NaCl}} \approx 10^{-21}\,\text{m}^2$; Urai et al. 1986). Volatiles generated during coalification cannot escape, building fluid pressure approaching lithostatic $P_{\text{fluid}} \to \sigma_v \approx 78\,\text{MPa}$ at 3 km depth. Under sealed conditions the effective rate enhancement factor:

$$\frac{r_{\text{sealed}}}{r_{\text{open}}} = \exp\!\left(\frac{\alpha E_a P_{\text{fluid}} V_a}{RTE_a}\right) \sim 10^3\text{–}10^4 \tag{36}$$

This sealed-system enhancement, combined with stress-induced rank enhancement of $\Delta R_o \sim 0.5$–$1.5\,\%$ at $\sigma_d \sim 150$–$200\,\mathrm{MPa}$, can produce anthracite-grade maturation at burial depths 20–30 % shallower than the open-system Barker calibration predicts.

Table 21: Mechanism summary for the Doberluger Synklinorium.

Observed feature	Physical cause (v7)	Diagnostic test
Steep dips 40°–60°	Plane-strain shortening, Andersonian thrust geometry	Bedding-trace mapping; T17
Fragmented seam blocks	Marginal shear zone, Fläming guide-rail friction	Microstructural analysis
Discordant Zechstein cover	Tectonic imbrication / pseudo-discordance, salt drape	Reflection seismic; T6
Anthracite at shallow depth	Pressure-cooker (sealed-system) + stress enhancement	R_o profile, bireflectance; T7
NE-SW & NNW-SSE faults	Conjugate stress field in funnel constriction	Palaeostress analysis

32. The Coal Corridor SU ↔ CK (new in v7)

A spatially coherent coalification corridor

The anthracite formation at Doberlug-Kirchhain — together with the important hard coal deposits in Saxony (the Döhlen Basin near Freital and the Lugau-Oelsnitz district) and in Lower Saxony (the Bielefeld area / Schaumburg / Barsinghausen / Ibbenbüren coals) — can be linked to the impact scenario: the Saale-Unstrut impactor and the Český Kráter impactor. These deposits are situated *precisely between the two impact sites*, in proximity to the kaolin deposits, and serve as possible evidence of the high-pressure shock and ground wave triggered by the adjacent impacts — a shockwave that may be requisite for the observed high-rank coalification at otherwise anomalously shallow depth.

The corridor structure documented along the Bramsche–SU–CK axis (§42) is identical to the corridor along which the high-rank coal anomalies are distributed:

- Lugau-Oelsnitz at ∼100 km from SU outer ring,
- Freital/Döhlen at ∼240 km from CK,
- Doberlug-Kirchhain in the inter-impact corridor between.

The spatial coincidence is geometrically tested by binomial analysis (analogous to the kaolin test of §30) and is statistically significant.

33. The Storegga Slide, Doggerland, and the Mercator Map Argument

33.1 Data Situation: Weninger et al. (2008)

Weninger et al. (2008) dated the Storegga Slide tsunami to:

$$^{14}\text{C age: } 7300 \pm 30\,^{14}\text{C-BP} \;\Rightarrow\; \text{cal. age: } 8100 \pm 100\,\text{calBP} \tag{37}$$

The slide involved 2,400−3,200 km^3 of material. Doggerland was undergoing continuous transgression and was, according to Weninger et al., catastrophically flooded by this event.

33.2 The *Albionis Pars* Argument

A Mercator map (1569) records *Albionis Pars* in the *Oceanus Germanicus*. This is read as a transmission witness of an early historical geographic reality. Two working hypotheses address the chronological gap (Storegga ≈8100 calBP; Ptolemy ≈150 AD): (a) the postulated 536 AD reactivation generated a new slide event in the northern North Sea; (b) parts of former Doggerland remained subaerially exposed through tectonic uplift compensation.

Working hypothesis status

Both scenarios remain working hypotheses. Falsifiable through high-resolution seismic profiles and isotope-stratigraphic boreholes covering the 5th–6th century AD transition.

34. Tsunami Sediment as a Mechanism of Northward Coastal Migration

For coastline length $L = 400\,\text{km}$, progradation distance $\Delta x = 120\,\text{km}$, and mean shallow-water depth $\bar{h} = 7.5\,\text{m}$:

$$V_{\text{required}} = L \cdot \Delta x \cdot \bar{h} = 400 \times 120 \times 0.0075\,\text{km}^3 = 360\,\text{km}^3 \tag{38}$$

Fraction of Storegga slide volume:

$$\frac{V_{\text{required}}}{V_{\text{Storegga}}} = \frac{360}{2800} \approx 12.9\,\% \tag{39}$$

Volumetric estimate

Deposition of merely ≈**13 %** of the Storegga slide volume in the southern North Sea / North German coastal zone would suffice to raise the seafloor by ≈7.5 m over a 120 km wide zone and a 400 km coastline.

The RSL index:

$$\eta(t) = \zeta(t) - \delta_{\mathrm{GIA}}(t) - \epsilon(t) \tag{40}$$

For the scenario postulated here, $\epsilon(t)$ increases by $\epsilon_0 > 0$, causing a negative RSL change on the North German side.

35. Prehistoric RSL Documentation and the Scandia Argument

Geersen et al. (2024) discovered the *Blinkerwall* in the Bay of Mecklenburg at 21 m water depth: a 971 m long Stone Age hunting architecture comprising 1,673 individual stones, dated to $9{,}143 \pm 36$ ^{14}C-BP; final submersion during the Littorina transgression (8.57–8.0 ka BP).

Two consequences for the Scandia hypothesis: (a) Scandia was substantially larger during the Stone Age, supporting the demographic pressure (*vagina nationum*) mechanism for the Gothic migration; (b) the Littorina transgression constitutes a documented analogue for the postulated rapid post-150 AD coastal change.

36. Integrated Evidence Assessment

Table 22: Summary of evidence chains (updated for v6).

Evidence Chain	Source	Support	Limitation
CDF/STZ reactivatability	Nielsen et al. (2007)	**strong**	Different timescale
Anomalous Quaternary subsidence	Arfai et al. (2018)	**moderate**	Reinterpretation
Kaolin clustering $p = 3.4 \times 10^{-5}$	Götze (2024); Kužvart (1992)	**strong**	Permian age; reframed
Storegga / Doggerland	Weninger et al. (2008)	**indirect**	Time lag ≈7,600 yr
Prehistoric RSL / Scandia	Geersen et al. (2024)	**strong**	Long-term RSL
Viséan protolith Doberlug	Daber (1959); Paech (1989)	**strong**	Protolith age; refines mechanism
Saale-Unstrut primary Sudete driver	this work, geometric audit	**strong**	Awaits geophysical confirmation (T1, T6)

Table 22 (continued)

Evidence Chain	Source	Support	Limitation
Danubius southern anchor (new v6)	this work, K4/G8	**strong**	Single-point c calibration; test with T10
G7 biaxial extrusion (new v6)	this work, geometric analysis	**moderate-strong**	$d_\perp = 5.2\,\mathrm{km}$; T9 confirmable

Part IV
The Saale-Unstrut Fragment Impact Hypothesis: Crustal Stress Fields, Biaxial Extrusion, Three-Scenario Impactor Analysis, and Revised Plausibility Assessment

37. Introduction to the Impact Hypothesis (Part IV)

Parts I–III established the cartometric, statistical, and geophysical foundations. Part IV develops the Saale-Unstrut Fragment Impact Hypothesis quantitatively and addresses: (i) the revised Sudete rotation mechanics under the corrected pivot; (ii) the biaxial G7 extrusion mechanism and its geometric derivation; (iii) the Herzberg 2024 earthquake correlation; and (iv) the updated plausibility assessment incorporating v6/v7 improvements.

1. Could the Saale-Unstrut Fragment Impact (postulated centre Schnellroda/Geiseltal, ≈11.73° E / 51.33° N; outer-ring centre Stolberg, ≈11.00° E / 51.57° N; outer deformation diameter 180–200 km; postulated date: late 530 or early 531 AD) be the primary local driver of both the Thüringer Wald rotation and (partially) the Elster-Cluster eastward displacement?

2. Is a primary crustal rupture driven by opposing tensional forces along the Bramsche–Český Kráter structural axis — with the Saale-Unstrut impact acting as a primary local driver within already critically pre-stressed crust — a physically coherent mechanism?

3. Does the instrumentally recorded M_L 3.1 earthquake of 18 October 2024 near Herzberg (Elster) and Doberlug-Kirchhain bear a geometrically and seismologically significant relationship to the residual stress field predicted by the block-translation model?

38. Pre-Displacement Geometry and Geology of the Crustal Gap Zone

38.1 Reconstructed Pre-Displacement Positions

The affine transformation implies an ENE displacement of $\overline{\Delta\lambda} = 93.1\,\text{km}$: $\Delta\lambda_{\text{shift}} = 93.1/(111.3 \times \cos(51.7°)) \approx 1.343°$.

Table 23: Reconstructed pre-displacement positions of the Elster Cluster.

Ptolemaic name	Current identification	Current coords	Pre-shift coords
Budorigum	Doberlug-Kirchhain	13.556°E / 51.619°N	≈12.213°E / 51.619°N
Limis Lucus	Baruth/Mark	13.499°E / 51.993°N	≈12.156°E / 51.993°N
Lugidunum	Falkenberg/Elster	13.271°E / 51.607°N	≈11.928°E / 51.607°N
Stragona	Herzberg/Elster	13.232°E / 51.682°N	≈11.889°E / 51.682°N

The four pre-shift positions cluster in the **Saale-Elbe confluence region** (11.89–12.21°E / 51.62–51.99°N). The eastern boundary of the Saale-Unstrut outer-deformation ring lies at:

$$\lambda_{\mathrm{E,ring}} = 11.000^\circ + \frac{77.5}{69.3} = 12.118^\circ\,\mathrm{E} \tag{41}$$

The mean pre-shift longitude ($\overline{\lambda}_{\text{pre-shift}} \approx 12.047^\circ$ E) falls within approximately 7 km of this boundary.

38.2 Geology of the Crustal Gap Zone

Table 24: Geological units in the Harz–Elbe-Elster crustal transect at ≈51.5° N.

Zone	Approx. λ	Principal formations	Mechanical character
Eastern Harz block	10.5–11.5°E	Devonian shales, Carboniferous granites	Rigid massif
Harzrand fault system	≈11.5°E	NW-SE Cretaceous inversion thrust	Active inversion zone
Saale-Unstrut Triassic Lands	11.5–12.2°E	Buntsandstein, Muschelkalk; **Zechstein evaporites**; **Geiseltal Eocene lignite** (≈11.73°E)	Weak cover above basement; Zechstein décollement
Halle Volcanic Complex	11.5–12.0°E	Lower Permian porphyries; phreatomagmatic breccias	Thermally preconditioned; primary fluid conduit
Halle Fault × L-R node	≈11.8°E	Conjugate fault arrays (NE-SW ∩ NW-SE)	Double-weakened node
Leipzig Embayment	12.2–12.7°E	Eocene–Miocene lignite	Thin-skinned; Zechstein décollement
Mulde-Elbe transition	12.7–13.1°E	Torgau-Dobritz Cretaceous Basin	Pre-existing tensional basin

Table 24 (continued)

Zone	Approx. λ	Principal formations	Mechanical character
Elbe Lineament	≈12.8–13.1°E	NW-SE crustal lineament; polyphase reactivation	**Primary discontinuity**
Elster-Lusatia	13.1–14.0°E	Lusatian Granodiorite (505–520 Ma); Viséan coals at Doberlug-Kirchhain	Ancient rigid block; backstop

The mechanically decisive property of the Harz–Elbe-Elster transect is the presence of Zechstein evaporites functioning as a regional décollement across the ≈70 km zone between 11.8–12.8°E — a well-documented feature of the Northeast German Basin (Scheck-Wenderoth et al., 2008).

39. Impact Mechanics: Shock Pressure and Transmission

39.1 Contact Pressure and Projectile Parameters

For a stony impactor ($\rho_i = 3{,}000\,\mathrm{kg\,m^{-3}}$, $L \approx 2.5\,\mathrm{km}$) striking at $v_i = 20\,\mathrm{km\,s^{-1}}$:

$$P_0 = \tfrac{1}{2}\,\rho_t\,c_t\,v_i = \tfrac{1}{2} \times 2{,}700 \times 6{,}000 \times 20{,}000 = 162\,\mathrm{GPa} \tag{42}$$

$$m_i = \rho_i \cdot \tfrac{4}{3}\pi\left(\tfrac{L}{2}\right)^3 \approx 2.45 \times 10^{13}\,\mathrm{kg} \tag{43}$$

$$\boxed{E_k = \tfrac{1}{2}\,m_i\,v_i^2 \approx 4.9 \times 10^{21}\,\mathrm{J}} \tag{44}$$

Pressure attenuation (Ahrens & O'Keefe, 1977):

$$P(r) = P_0\left(\frac{r_0}{r}\right)^n, \quad r_0 = L/2 = 1{,}250\,\mathrm{m}, \quad n = 2.5 \tag{45}$$

39.2 Pressures at Key Structural Targets

Table 25: Shock pressure at principal geodynamic target structures.

Target structure	r	$P(r)$	Threshold	Assessment
Inner crater rim	16 km	120 MPa	—	breccia / suevite
Halle Fault × L-R	40 km	25 MPa	1–10 MPa	**reactivated**
Kyffhäuser block	46.5 km	18 MPa	10–25 MPa	**fractured**
Stolberg outer ring	57 km	10 MPa	1–10 MPa	**reactivated**
Thüringer Wald spine	80–100 km	4–7 MPa	1–10 MPa	**rim deformation**
Elbe Lineament (Torgau)	90 km	3.5 MPa	1–10 MPa	at threshold
Senftenberg backstop	157 km	0.89 MPa	1–10 MPa	insufficient (direct)
Doberlug-Kirchhain	178 km	0.6 MPa	1–10 MPa	overthrust fringe
CDF main trace	280 km	0.21 MPa	1–10 MPa	insufficient (single fragment)

The 4–7 MPa pressure at the Thüringer Wald spine (80–100 km from impact centre) is at the upper limit of the fault-reactivation range and consistent with the rim-deformation interpretation of §11.

For a stony impactor ($\rho_i = 3{,}000\,\mathrm{kg\,m^{-3}}$, $L \approx 2.5\,\mathrm{km}$, $v_i = 20\,\mathrm{km\,s^{-1}}$):

$$P_0 = \tfrac{1}{2}\,\rho_t\,c_t\,v_i = 162\,\mathrm{GPa} \tag{46}$$

$$\boxed{E_k = \tfrac{1}{2}\,m_i\,v_i^2 \approx 4.9 \times 10^{21}\,\mathrm{J}} \tag{47}$$

Pressure at the Thüringer Wald spine (80–100 km): 4–7 MPa — at the upper limit of fault-reactivation and consistent with rim-deformation interpretation.

39.3 Fault-Guided Wave Amplification

For seismic energy channelled along the Elbe Lineament ($n_{\mathrm{guided}} \approx 1.5$; Aki 1979), the pressure at 157 km is amplified to:

$$P_{\mathrm{guided}}(157\,\mathrm{km}) = 162 \times 10^3\,\mathrm{MPa} \times \left(\frac{1.25 \times 10^{-3}}{157}\right)^{1.5} \approx 115\,\mathrm{MPa} \tag{48}$$

With realistic dissipation (factor 10–30), effective guided pressure is ≈4–12 MPa — within the reactivation threshold for pre-weakened Lusatian Overthrust fault segments.

40. G7 Biaxial Lateral Extrusion: Geometric Derivation

40.1 Observed Displacement Azimuth

Under $c = 15.2\,\mathrm{km}/^{\circ}_{P}$:

$$\Delta E = +93.9\,\mathrm{km}, \quad \Delta N = +70.6\,\mathrm{km} \tag{49}$$

$$\theta_{G7} = \arctan\left(\frac{93.9}{70.6}\right) = \mathbf{53.0}^{\circ}\ (\mathrm{NNE}) \tag{50}$$

$$|\Delta_{G7}| = \sqrt{93.9^2 + 70.6^2} = \mathbf{117.5}\,\mathrm{km} \tag{51}$$

40.2 Expected Biaxial Extrusion Azimuth

SU–CK axis (Geiseltal → Tábor) azimuth:

$$\theta_{\mathrm{Achse}} = \arctan\left(\frac{208.4}{212.6}\right) + 90^{\circ} = 44.4^{\circ} + 90^{\circ} = \mathbf{134.4}^{\circ}\ (\mathrm{SSE}) \tag{52}$$

Lateral extrusion perpendicular to compression axis:

$$\theta_{\mathrm{Extrusion}} = 134.4^{\circ} - 90^{\circ} = \boxed{44.4^{\circ}\ (\mathrm{NNE})} \tag{53}$$

$$\Delta\theta = \theta_{G7} - \theta_{\mathrm{Extrusion}} = 53.0^{\circ} - 44.4^{\circ} = \mathbf{8.6}^{\circ} \tag{54}$$

Geometric match: G7 biaxial extrusion

The observed G7 displacement azimuth (53°) deviates only 8.6° from the theoretically expected biaxial extrusion perpendicular (44.4°) — well within the combined geometric model uncertainty of ±10–15°. The 8.6° eastward bias is explained by SU down-range coupling adding a small ENE component to the lateral extrusion.

40.3 G7 Pre-Deformation Position on the Biaxial Axis

$$\lambda_{\mathrm{pre,G7}} = 14.467 - \frac{93.9}{70.0} = 13.126^{\circ}\mathrm{E} \tag{55}$$

$$\phi_{\mathrm{pre,G7}} = 51.133 - \frac{70.6}{111.3} = 50.499^{\circ}\mathrm{N} \tag{56}$$

Perpendicular distance from the SU–CK axis to the G7 pre-deformation position:

$$d_{\perp} = 98.0 \times 0.714 + (-92.5) \times 0.700 = 69.97 - 64.75 = \boxed{+5.2\,\mathrm{km\ NE}} \tag{57}$$

G7 essentially on the biaxial axis

G7's pre-deformation position lies only 5.2 km from the SU–CK compression axis — essentially *on the axis*. A body on the axis experiences *maximum* lateral extrusion force. This geometric arrangement is non-coincidental and provides strong support for the biaxial extrusion interpretation.

40.4 SU vs. CK Contribution to G7 Extrusion

Distance from G7-predisplacement to Geiseltal: 134.7 km; to Tábor: 163.1 km. Inverse-distance weighting: SU ≈ 55%, CK ≈ 45%. This partition is consistent with the trigger-budget apportionment of §14.

41. The CDF: Multi-Fragment Activation

Direct isotropic shock at the CDF ($r \approx 280$ km): $P \approx 0.21$ MPa — below reactivation threshold. Multi-fragment + Africa-impactor framework is required (§14). GISP2 records four discrete chondritic particle horizons in 533–540 AD (Abbott et al., 2014), providing cosmochemical confirmation.

42. The Bramsche–Český Kráter Biaxial Stress Field

The structural corridor (Bramsche → Geiseltal → Tábor, azimuth ≈ 120°, total 530 km) pre-loads the crust to within 5 MPa of Coulomb failure:

$$|\tau|_{\text{crit}} = c_0 + \mu_s \, \sigma_n' = 2 + 0.6 \times 5 = 5 \,\text{MPa} \tag{58}$$

This pre-loading makes the Saale-Unstrut impact the most parsimonious trigger within the corridor.

43. The Elbe Lineament as Primary Transmission Channel

The Elbe Lineament (≈500 km, NW–SE, ≈ 310°/130°) intersects the impact shock field at $r \approx 85$–90 km (pressure: 3.5–7 MPa). The NW–SE orientation is geometrically perpendicular to the ENE block displacement — mechanically optimal for dextral transpressive rupture in a Riedel shear geometry. Pre-existing dextral kinematics from Late Cretaceous inversion tectonics (Scheck-Wenderoth et al., 2008) dramatically reduce the required trigger energy.

44. Crustal Translation Kinematics: The −93 km Block Displacement (v6 formulation)

The v6 translation-glide formulation preserves the energy coherence. Translation work along the Zechstein décollement ($\mu \approx 0.1$, $V \approx 2.8 \times 10^4\,\mathrm{km}^3$, $\Delta x = 93\,\mathrm{km}$):

$$W_{\mathrm{translation}} \approx 0.1 \times 6.7 \times 10^{16} \times 9.81 \times 93 \times 10^3 \approx 6 \times 10^{21}\,\mathrm{J} \tag{59}$$

This is of the same order as $E_k \approx 4.9 \times 10^{21}\,\mathrm{J}$ of the Saale-Unstrut impact, achievable when two co-temporal impacts and the CDF pulse are summed. The translation-glide kinematics is *energetically achievable* where the rigid-rotation formulation of v4 was not.

45. The Český Kráter at Tábor: Structure and Alpine-Carpathian Geodynamics

Structural parameters of the Tábor / Bohemian Massif impact hypothesis, the Alpine-Carpathian bow-shock morphology, and the Bavarian Dark Earth hydrodynamic mechanisms are as described in in (Section 45) of this paper. The younger age interpretation (≈525–531 AD) is retained; the conventional ≈2 Ga Rajlich age is attributed to inheritance of pre-existing zircon ages.

46. The Herzberg Earthquake of 18 October 2024: Spatial Correlation Analysis

46.1 Seismological Parameters

Table 26: Instrumental parameters of the Herzberg (Elster) earthquake, 18 October 2024.

Parameter	Value	Source
Date / UTC	18 Oct 2024, 10:50:52	BGR, USGS
Magnitude	M_L 3.1 (BGR) / 3.2 (Uni Jena)	Instrumental
Hypocentre depth	≈21 km (±5 km)	Uni Jena
Epicentre area	Herzberg (Elster) – Doberlug-Kirchhain	BGR
Prior seismicity	None in BGR catalogue	BGR
Historical analogue	Herzberg 1483, intensity IV	City chronicle
Aftershocks	None detected	Instrumental

The 21 km hypocentre depth rules out anthropogenic causes. The absence of aftershocks is consistent with a complete stress-drop event on a small, isolated residual fault patch in the down-range overthrust zone. The predicted ellipse focus F_2 of the compressed Vistula meander (≈ 13.519°E / 51.783°N) lies ≈ 16.9 km from the

BGR epicentre centroid — within the combined uncertainty envelope. The interval 1483 → 2024 (541 yr) is consistent with a residual tectonic scar accumulating stress through Africa-Europe convergence.

46.2 The Elliptical Deformation Model and Predicted Stress Maxima

The compression of the ancient circular Vistula meander ($R_0 \approx 28.4\,\text{km}$; centre Domsdorf, 13.61°/51.57°) to an ellipse with $a = 28.4\,\text{km}$, $b = 14.2\,\text{km}$:

$$e = \sqrt{1 - b^2/a^2} = 0.866, \quad c = e \cdot a = 24.6\,\text{km} \tag{60}$$

The elastic stress concentration factor at the ellipse foci (Inglis, 1913):

$$K_t = 1 + 2\sqrt{a/b} = 1 + 2\sqrt{2} \approx 3.83 \tag{61}$$

46.3 Distance Between Predicted Focus and Observed Epicentre

The second ellipse focus F_2, lying $c = 24.6\,\text{km}$ NNW of the ellipse centre:

$$\lambda_{F_2} = 13.610^\circ - \frac{24.6 \times \sin(15^\circ)}{69.3} = 13.519^\circ\,\text{E} \tag{62}$$

$$\phi_{F_2} = 51.570^\circ + \frac{24.6 \times \cos(15^\circ)}{111.3} = 51.783^\circ\,\text{N} \tag{63}$$

Predicted stress focus F_2

$F_2 \approx 13.519^\circ\,\text{E} / 51.783^\circ\,\text{N}$ (Nexdorf–Schilda area, north of Herzberg/Elster)

The BGR epicentre centroid (≈13.400°/ 51.650°):

$$d(F_2,\ \text{EQ}_{2024}) = \sqrt{8.2^2 + 14.8^2} \approx \mathbf{16.9}\,\text{km} \tag{64}$$

The 16.9 km discrepancy falls within the combined uncertainty envelope (±12–21 km). The predicted focus F_2 was derived independently of seismological data, making its spatial coincidence with the only $M_L > 3$ earthquake in the instrumental history of this area a non-trivial predictive result.

46.4 Recurrence Interval and Stress-Relaxation Cycle

The Herzberg city chronicle records a macroseismic event in 1483 (intensity $I \approx$ IV). The interval 1483 → 2024 is **541 years** — consistent with a residual tectonic scar accumulating stress through Africa-Europe convergence and releasing it episodically.

47. Historical and Mythological Corroboration

47.1 Convergence of Independent Evidence Chains

Table 27: Independent evidence converging on a catastrophic central European event, 525–540 AD.

Evidence category	Source	Event / Observation	Spatial bearing
Cosmochemistry (ice core)	Abbott et al. (2014); GISP2	4 discrete chondritic particle horizons, 533–540 AD	Global; fragmented cometary source
Dendroclimatology	Multiple tree-ring records	Anomalous cold / dim years, 536–545 AD	N Hemisphere
Historical (court)	Procopius of Caesarea, *De Bellis*, c. 550	Sun "without rays, like the moon" for 18 months	Eastern Mediterranean
Historical (court)	Cassiodorus, *Variae*, c. 537	"Summer without heat"; anomalous solar dimming	Italy / W Mediterranean
Historical (ecclesiastical)	Michael the Great of Syria, *Chronicle* (12th c.)	Fire from heaven; dark/black flood waters; bones and skeletons of wild animals appearing at the surface	SE Mediterranean, SW Asia
Historical (civic)	Chronicle of Edessa, c. 525 AD	Flood "from the mountains, striking the walls"	Mesopotamia
Astronomical	Halley's Comet, 530 AD	Documented perihelion; possible fragmentation	Near-Earth orbit
Political-historical	Gregor of Tours, c. 575	Fall of the Thuringian Kingdom at the Unstrut, 531 AD	Directly above postulated Saale-Unstrut impact zone
Archaeological	LDA Sachsen-Anhalt survey	Settlement hiatus, Halle–Köthen–Merseburg zone, 5th–6th c. AD	Directly above postulated inner crater
Archaeological	Elsterwerda excavations	Abrupt termination of ≈200 iron-smelting furnaces	Elster Cluster domain

Table 27 (continued)

Evidence category	Source	Event / Observation	Spatial bearing
Ethnological	Volkmann (2014)	Abrupt culture collapse, 5th–6th c. AD	Oder-Saale domain
Seismology	BGR / Uni Jena (2024)	M_L 3.1, depth 21 km, no prior seismicity	Predicted ellipse focus F_2

47.2 The Chronicle of Michael the Great of Syria

The *Chronicle of Michael the Great* (Patriarch of Antioch, 1126–1199 AD; principal edition Chabot 1899–1910) contains two passages of specific relevance:

On the flood waters. Michael describes inundations whose waters appear dark or black. This is identified as congruent with the ED-E hypothesis: a catastrophic flood wave carrying a suspension of carbonised organic material (lignite dust, charred vegetation, dark impact ejecta) would produce water of distinctively blackish appearance. The black sediment deposited by such an event — preserved as an anomalous dark soil horizon — constitutes the diagnostic ED-E marker layer.

On the bones and skeletons of wild animals. The Chronicle states "one saw the bones and skeletons of wild animals appear at the surface of the earth." This is connected with the **Geiseltal fossil fauna**: an Eocene (≈44–47 Ma) mammalian assemblage of exceptional completeness. An impact excavating the Geiseltal Eocene lignite and associated fossiliferous horizons would have brought fossil remains to the surface. Whether these remains represent excavated ancient fossils or contemporaneous fauna killed by the impact cannot be resolved without systematic dating; both interpretations remain open.

47.3 The Thuringian Kingdom, the Nibelungenlied, and the Kyffhäuser Legend

The political collapse of the Thuringian Kingdom at the battle of the Unstrut (c. 531 AD) lacks verified archaeological evidence at the named battle sites. The Unstrut valley falls directly within the postulated inner structural ring of the Saale-Unstrut impact.

The Kyffhäuser (11.07°E / 51.41°N) lies 46.5 km WSW of the impact centre; the shock pressure:

$$P(46.5\,\mathrm{km}) = 162 \times 10^3\,\mathrm{MPa} \times \left(\frac{1.25 \times 10^{-3}}{46.5}\right)^{2.5} \approx 18\,\mathrm{MPa} \tag{65}$$

This substantially exceeds the compressive strength of Kyffhäuser limestone and sandstone (10–25 MPa), meaning massive rockfall, cavity formation, and a fire-glow appari-

tion in the WNW sky would objectively have occurred. The cyclical awakening motif of the Kyffhäuser legend encodes the episodic seismic reactivation at recurrence intervals of ≈500–600 yr.

Four GISP2 chondritic particle horizons (533–540 AD), Byzantine court chronicles, Edessa flood reports, settlement hiatus over the impact centre, and the simultaneous collapse of the Thuringian Kingdom all converge on a catastrophic central European event in 525–540 AD. Michael the Great's reports of dark flood waters and surface-exposed animal bones are consistent with the ED-E model and the Geiseltal Eocene fossil excavation mechanism respectively.

48. Three-Scenario Impactor-Size Analysis (new in v7)

The energy required to drive the observed deformation ($W_{\mathrm{tr}} \approx 6 \times 10^{21}$ J for the −93 km Elster translation) can be supplied by several plausible impactor configurations.

Table 28: Three impactor-size scenarios bracketing the v7 model uncertainty.

Scenario	Impactor characterisation	Energy budget	Fit to evidence
A′ (multi-fragment)	N fragments at 100–300 m, $v_i \approx 20\,\mathrm{km\,s^{-1}}$	$\sum E_k \sim 10^{20}$ J cumulative	**Main scenario**: consistent with GISP2 four chondritic horizons in 533–540 AD; requires biaxially pre-loaded crust as amplifier; $\eta_{\mathrm{eff}} \approx 0.3$–$0.5$ at Coulomb threshold; no single crater >50 km required
B (single dominant)	Single 500 m–1 km stony impactor at the Geiseltal/Schnellroda inner crater; $v_i \approx 20\,\mathrm{km\,s^{-1}}$	$E_k \sim 10^{20}$ J	Most parsimonious for dual-rotation symmetry about Waltershausen (Sudete +35°CW; southern Abnobae ∼−22°CCW) as a single impulsive source; crater ∼15–20 km, potentially buried under Zechstein
C (large)	2–5 km stony impactor	$E_k \sim 10^{22}$–10^{23} J	Geometrically sufficient; energetic surplus; harder to reconcile with multi-horizon GISP2 record unless the larger impactor was one of several fragments; expected crater >65 km would be detectable

Evaluation: Scenario A′ (multi-fragment) is optimum for v7

Why A′ rather than B as main scenario: The geometric symmetry of the dual rotation around the single Waltershausen pivot is consistent with a single dominant source (Scenario B), but the four discrete GISP2 chondritic horizons (533–540 AD) are more naturally explained by a cometary fragment cluster. Optimal coupling efficiency ($\eta_{\text{eff}} \approx 0.3$–$0.5$) at the biaxially pre-loaded Coulomb threshold requires no additional amplification and does not demand a single crater > 50 km — which is absent from the currently recognised impact catalogue. Scenarios B and C are not ruled out; they bracket the uncertainty below and above. Scenario C (> 2 km monolith) is disfavoured because the expected crater > 65 km would be detectable in modern geophysical surveys.

48.1 The Rajlich Structure and Younger Age Interpretation

Rajlich (2007); Rajlich et al. (2009) identify a multi-ring impact astrobleme in the Bohemian Massif with the following characteristics:

- **Outer ring diameter:** up to 540–600 km
- **Inner crater diameter:** ≈300 km
- **Moho depression:** up to 40 km depth
- **Impact evidence:** shocked quartz (PDFs), pseudotachylite veins, microdiamonds, moissanite (SiC), coesite, UHP mineral assemblages
- **Conventional age:** ≈2 Ga (Proterozoic)

A substantially younger age is proposed: the Ptolemaic *Geographia* (c. 150 AD) documents the Elster Cluster in the eastern Harz foreland — not yet displaced. The displacement must postdate 150 AD. The postulated date of ≈525–531 AD is consistent with all available historical and natural-scientific evidence. The conventional ≈2 Ga Rajlich age is attributed to inheritance of pre-existing zircon ages from the ancient Proterozoic basement.

48.2 Structural Parameters

Table 29: Structural parameters of the Tábor / Bohemian Massif impact hypothesis.

Parameter	This model	Rajlich reference	Notes
Impact centre	Near Tábor (14.67°/ 49.42°)	Mladá Vožice (≈14.55°/ 49.52°)	Rajlich more precise
Inner crater diameter	80–90 km	≈300 km	Sub-structure identified
Outer crater diameter	250–300 km	540–600 km	Outer ring within ancient ring
Long ellipse axis	≈100°WNW-ESE	Multiple ring generations	Consistent with WNW approach
Approach azimuth	≈280°(from WNW)	Pre-crater faults at ≈020°–200°	WNW approach consistent

48.3 The Alpine-Carpathian Bow-Shock Morphology

The orographic Alps–Vienna–Carpathians configuration is attributed to the Tábor / Bohemian Massif impactor. With a WNW approach vector (≈280°) and impact centre at Tábor, the crustal compression was asymmetric: the starboard side contributed to the Alpine arc; the port side to the Carpathian arc; the Vienna Basin marks the structural apex; and the Bratislava Gate represents the structural break-point.

48.4 Bavarian Dark Earth Horizons: Hydrodynamic Mechanisms

The *Dark Earth* destruction layers at Roman-period settlements in the Bavarian Danube region are attributed to two mechanisms:

Primary mechanism (direct impact or atmospheric airburst): Whether the relevant fragment detonated as an airburst at 30–40 km altitude or impacted in the Bohemian Massif, enormous volumes of water would be sublimated or excavated, generating catastrophic hydrometeors and lahars across the Bohemian Forest and Danube headwater region:

$$Q_{\text{sublim}} = m_{\text{ice}} \times L_{\text{sublim}} \approx 2.6 \times 10^{11}\,\text{kg} \times 2.83 \times 10^{6}\,\text{J kg}^{-1} \approx 7.4 \times 10^{17}\,\text{J} \qquad (66)$$

Secondary mechanism (hydraulic injection from the east): The Edessa chronicle (c. 525 AD) reports a flood "from the mountains, striking the walls, withdrawing, striking again" — physically consistent with a seiche oscillation. Far-field seismicity of the Tábor impact could have triggered such oscillations in the Pannonian Basin or displaced water masses through the Bratislava Gate northwestward.

49. Integrated Plausibility Assessment (v7)

The v5 score (105/140, ≈75%) is updated in v6 by adding new dimensions for the Danubius anchor, bias calibration, G7 biaxial extrusion, and pivot clarification. The v7 version now becomes the Cumulative score (v7): $142/180 \approx 79\,\%$.

Table 30: Composite plausibility scores (v7). Net gain from new sub-aspects; v6 score 115/155 → v7 upgraded.

Dimension	Sub-aspect	Score	Key factor
Geometric coherence	Oblique impact axis Bramsche–SU–CK	4/5	angular scatter ≈18°
	SU outer rim = Oberhof–Ilmenau	4.5/5	geometrically clean fit
	Pre-shift cluster at outer ring boundary	4/5	quantitatively verified
	Elbe-Elster as down-range lobe	4/5	resolves SU vs. rim tension
	G7 on SU–CK axis ($d_\perp = 5.2\,\mathrm{km}$) [v6]	4.5/5	non-coincidental; maximises extrusion force
Impact physics	Direct shock at Elbe Lineament	3/5	lower threshold
	Fault-guided transmission	4/5	Elbe Lineament waveguide
	CDF activation by single SU	1/5	insufficient; multi-fragment req.
	Multi-fragment scenario (GISP2)	3.5/5	supported
	Biaxial Bramsche–CK pre-loading	4/5	well-supported
	SU = primary Sudete driver	4.5/5	50–60 km rim displacement
	G7 biaxial extrusion ($\Delta\theta = 8.6°$) [v6]	4.5/5	azimuth match within uncertainty
Geological evidence	Zechstein décollement	4/5	independently established
	Doberlug Viséan + SU overprint	4/5	geologically defensible
	Elbe Lineament dextral kinematics	4/5	Late Cretaceous precedent

Table 30 (continued)

Dimension	Sub-aspect	Score	Key factor
	Multi-layer factor 2.4 kinematics	4/5	hard to explain otherwise
Český Kráter model	Ring fracture to Saxon-Lusatian domain	4/5	
	Tábor younger age	2.5/5	no independent dating
	Alpine-Carpathian bow-shock	3/5	FE-modelling needed
Historical record	GISP2 chondritic horizons	5/5	direct confirmation
	Settlement hiatus over impact centre	4/5	well-documented
	Fall of Thuringian Kingdom	3.5/5	spatial coincidence
	Michael the Great: dark flood waters	3.5/5	consistent
	Michael the Great: bones/skeletons	3/5	speculative
Herzberg 2024	$F_2 \leftrightarrow$ epicentre, 16.9 km	3.5/5	within uncertainty
	Hypocentre 21 km depth	4/5	non-anthropogenic
	541-yr recurrence	3/5	single interval
Kinematic taxonomy (v5)	Elster T-G (Senftenberg backstop)	4.5/5	geometrically consistent
	Sudete rigid rotation +35°	4.5/5	2% distance preservation
	Trigger budget self-consistency	3.5/5	multi-trigger superposition
	Main-valley buckling	3/5	suggestive; FE needed
v6 additions	Danubius K4 bias calibration	4.5/5	G6 $r_{\text{corr}} = 12.0$ km; internally consistent
	SSE component (-16.1 km, $p = 0.035$)	3.5/5	marginal; sens. to c
	Pivot clarification (G5 $\neq$ pivot)	4/5	structurally consistent; T9 testable
	Anduaetium / Bamberg hypothesis	2.5/5	large uncertainty ± 100 km; T10
v7 additions	**universal-pivot consistency**	**5/5**	

Table 30 (continued)

Dimension	Sub-aspect	Score	Key factor
	Abnobae unified hypothesis	**4.5/5**	
	Rhenus/Danubius source identification	**4/5**	
	coal corridor	**3.5/5**	
	Erzgebirge interference grid	**3/5**	
	revised trigger budget	**4.5/5**	**physically motivated**
	Vistula proportional cross-check	**5/5**	**decisive**
	Ottendorf artesian system	**3.5/5**	
	Erzgebirge interference grid	**3/5**	
	extended EC	**5/5**	$t = -19.1$
Falsifiability	T1 shock-quartz drill programme	5/5	definitive
	T2 Bouguer anomaly ring survey	4/5	executable
	T6–T8 (v5) + T9–T11 (v6)	4/5	specific predictions
Cumulative score (v7)		**142/180**	**≈79 %**: improvement to v6;

Part V
The Unified Abnobae Mons Hypothesis: A New Constraint on the Universal Pivot and the Pre-Deformation Geography

50. The Unified Abnobae Mons: Geological Setting and Pre-Deformation Geometry

50.1 Motivation

The Ptolemaic *Abnoba Mons* is traditionally identified either narrowly (with the Black Forest) or, in v6, with the Taunus as its western terminus (K4). Tacitus (*Germania* 1) records *Danuvius molli et clementer edito montis Abnobae iugo effusus* — 'the Danube flows out of the gently and softly elevated ridge of the Abnoba mountains.' The classical sources thus describe a *single coherent ridge*, not a fragmented system.

In the modern topography, the geography west of the Bohemian Massif consists of five separate uplands (Taunus, Odenwald, Spessart, Vogelsberg, Rhön) bounded by various Cenozoic rift and basin systems. The new v7 hypothesis is that the Ptolemaic Abnoba Mons corresponds to a **pre-deformation unified crustal block** encompassing all of these elements, and that the modern fragmentation is the direct geomorphological result of the 6th-century deformation.

50.2 Structural Identification

The unified Abnobae block in this interpretation comprises:

- the modern **Taunus** (Rhenohercynian Zone, NW segment, *stable*);
- the modern **Odenwald** and **Spessart** (Mid-German Crystalline High / Saxothuringian), *mobile* southern segment;
- the modern **Rhön** (Saxothuringian affinity, NE peripheral element of the mobile block);
- the **pre-Vogelsberg basement** (now buried beneath the Miocene basalts of the Vogelsberg volcanic field).

50.3 The Hunsrück–Taunus Boundary Fault (HTBF) as Active Separator

The northern boundary of the mobile southern Abnobae block is the documented **Hunsrück–Taunus Boundary Fault (HTBF)** / Taunus-Südrandstörung (ENE-striking structural front of the Rhenish Massif). The fault separates: (N, stable) Taunus, Westerwald, Kellerwald, Rothaargebirge; (S, mobile) Odenwald, Spessart,

Rhön, pre-Vogelsberg basement.

50.4 The Southern Boundary of the Mobile Block

The southern boundary is approximated by the Wiesloch(Heidelberg) – Aschaffenburg – Schlüchtern – Bad Kissingen line, intersecting documented fault zones including the Otzberg Zone, the URG eastern border fault near Darmstadt, and the Kissingen-Haßfurt fault zone.

51. The Waltershausen Universal Pivot: Quantitative Geometry

51.1 Lever-Arm Computation for the Southern Abnobae

For the Waltershausen pivot $P \approx 10°33'\text{E} \,/\, 50°53'\text{N}$ (i.e. $\lambda_P = 10.542°$, $\phi_P = 50.882°\text{N}$), the lever arm from P to the present Amorbach reference is:

$$\begin{aligned} \Delta x &= (9.22 - 10.54) \times 71.5\,\text{km}/^\circ = -94.4\,\text{km} \\ \Delta y &= (49.65 - 50.88) \times 111.3\,\text{km}/^\circ = -136.9\,\text{km} \\ R_{\text{Amorbach}} &= \sqrt{94.4^2 + 136.9^2} \approx 166\,\text{km} \end{aligned} \tag{67}$$

This is essentially identical to the v6 lever arms to G5 (≈86 km) and G6 (≈90 km) in the sense that the Sudete–Amorbach pair both lie within the ∼160–170 km radial shell around P — a geometric circumstance with very low coincidence probability.

51.2 Inverse Rotation of the Amorbach Point

Applying an inverse rotation of $+22°$ (CW) about P to the modern Amorbach position ($\lambda = 9.22°\text{E}$, $\phi = 49.65°\text{N}$):

$$\begin{aligned} x_0 &= x\cos 22^\circ + y\sin 22^\circ = (-94.4)(0.927) + (-136.9)(0.375) = -138.8\,\text{km} \\ y_0 &= -x\sin 22^\circ + y\cos 22^\circ = (+94.4)(0.375) + (-136.9)(0.927) = -91.5\,\text{km} \end{aligned} \tag{68}$$

yielding pre-deformation coordinates:

$$\lambda_{R_0} = 10.542 - 138.8/71.5 = \mathbf{8.60}°\text{E}, \quad \phi_{R_0} = 50.882 - 91.5/111.3 = \mathbf{50.06}°\text{N} \tag{69}$$

The displacement chord is:

$$d_R = \sqrt{(94.4 - 138.8)^2 + (136.9 - 91.5)^2} \approx 63.5\,\text{km} \tag{70}$$

51.3 The Danubius Source Identification

Applying the same inverse rotation to the Marktheidenfeld representative point (9.55°E / 49.75°N) yields:

$$(\lambda_{D_0},\, \phi_{D_0}) \approx (8.96°\text{E},\ 50.07°\text{N}), \quad d_D \approx 55\,\text{km} \tag{71}$$

51.4 Pre-Deformation Inter-Source Distance

$$d_{R_0D_0} = \sqrt{((8.96 - 8.60) \times 71.5)^2 + ((50.07 - 50.06) \times 111.3)^2} \approx \mathbf{26}\,\text{km} \tag{72}$$

On the Mercator 1569 world map (scale $\sim 1 : 3.5 \times 10^6$), this distance corresponds to a cartographic separation of approximately 0.7 mm — consistent with Mercator's depiction of the two sources as essentially coincident.

51.5 Mercator Cartographic Test

Three independent Mercator-1569 signatures diagnostic of the pre-531 AD state

1. **Unified Abnobae Mons.** Mercator depicts the central German uplands as a continuous ridge, not as separately differentiated Taunus / Odenwald / Spessart / Rhön. This is the pre-531 AD configuration of the unified block.
2. **Straight Danubius.** The Main (=Danubius) on Mercator's map is rendered as a generalised east-flowing river without the dramatic Maindreieck/Mainviereck double-bend. This is the pre-buckling configuration.
3. **Sources close together.** The Rhenus source is depicted just southwest of the Danubius source, on the same Abnobae ridge. This is exactly the predicted pre-deformation configuration with inter-source distance ∼26 km.

The combination of three independent cartographic features all matching the pre-531 AD predictions of the kinematic model constitutes strong cartometric corroboration of the unified Abnobae hypothesis.

52. The Vogelsberg/Wetterau as Pull-Apart Filling

52.1 The Kinematic Role

The Vogelsberg volcanic field (Miocene, ∼18.5–10 Ma, basalt volume ∼700 km^3) occupies the geometric position between the stable Rhenohercynian block (Taunus / Kellerwald, N) and the mobile MCZ / Saxothuringian block (Odenwald / Spessart / Rhön, S) during the cumulative SE-ward drift of the southern block. The earlier v6 interpretation of the Vogelsberg as a 'backstop' was geometrically inconsistent and is here corrected: the **Vogelsberg is the pull-apart filling**, the surface expression of Miocene to recent decompression-melting magmatism that ascended through the progressively opening

rift.

Vogelsberg structural role: pull-apart filling (not backstop)

The Vogelsberg lies *between* the northern and southern Abnobae units. It cannot therefore have been the structural arrester of the rotation. The correct interpretation: the Vogelsberg opened as a **pull-apart gap** in the widening space between the stable Taunus/Kellerwald block (N, fixed against the HTBF) and the southward-migrating MCZ/Saxothuringian block (Odenwald/Spessart/Rhön, S). Pull-apart opening commenced in the Miocene (∼18.5 Ma) and the resulting extensional void was progressively filled by decompression-melting basalts rising from the asthenosphere.

Knüll correlation: The Knüll basalts (∼14–7 Ma) lie ≈45–55 km NNE of the Vogelsberg centre and ≈7.8 km north of the Waltershausen-Pivot latitude (50.882°N vs. 50.95°N at Knüll centre). They document a long-lived lithospheric weakness zone at the bookshelf-shear relay between HTBF and Otzberg-Zone — the same zone that the model identifies as the locus of maximum deformation energy exchange. The Knüll basalts are endogenous OIB-type, unambiguously Miocene, and not 6th-century ejecta.

52.2 The Two-Phase Rotation Interpretation

The cumulative ∼80–90 km SE-ward drift of the southern Abnobae block is interpreted as the sum of:

- **Phase 1 (Miocene, ∼18.5–10 Ma):** Progressive pull-apart opening, basalt extrusion, slow SE displacement of the southern block; ∼80 % of cumulative displacement.
- **Phase 2 (post-antique, ∼531 AD):** Final ∼20 % increment of ∼60–70 km cartometrically recoverable from the Ptolemaic record; possible phreatomagmatic reactivation in pre-existing Vogelsberg maar conduits but no new major basalt magmatism.

This two-phase interpretation reconciles the v7 cartometric displacement claim with the Miocene radiometric and palaeomagnetic data on the Vogelsberg, which constrain the main volcanic phase to ∼18.5–10 Ma without contradiction.

52.3 The Rhön as NE Peripheral Element

The Rhön (volcanic phonolites, ∼25–11 Ma) lies closer to the Waltershausen pivot than Amorbach (lever arm ∼61 km vs. 166 km) and therefore experienced a much smaller displacement under the same −22° rotation (chord displacement ∼23 km). The modern position is the post-rotation position, ∼19 km south of the pre-rotation position depicted by Mercator.

53. The River Capture: Mud/Mümling from proto-Rhenus to Main

The Mud (Amorbach) was originally a NW-flowing tributary of the proto-Rhenus, but the SE rotation of the southern Abnobae block reorganised the drainage so that the Mud now flows into the Main at Miltenberg. The Miltenberg-to-Mainz reach of the modern Main is interpreted as the structural relict of the proto-Rhenus upper course.

54. Falsifiability of the Unified Abnobae Hypothesis

Beyond Mercator-1569 cartographic verification, the unified hypothesis is falsifiable through:

T15:

Wind-gaps and palaeo-drainage indicators in the Mud/Mümling area.

T19:

GPS cross-profile across the HTBF detecting residual differential motion between Taunus and Odenwald.

T20:

Rhön xenolith chronometry: palaeomagnetic and isotopic affinity with MCZ basement confirming the unified Abnobae pre-deformation block.

T21:

Vogelsberg $^{40}\mathrm{Ar}/^{39}\mathrm{Ar}$ age gradient: NW (older) $\rightarrow$ SE (younger) systematic gradient consistent with progressive pull-apart opening.

T22:

Ptolemaic Rhenus/Danubius source-coordinate test: predicted positions ($\lambda_P \approx 33°$, $\phi_P \approx 47°$ for Rhenus; $\lambda_P \approx 34°$, $\phi_P \approx 47°$ for Danubius). Direct decisive test against original *Geographike Hyphegesis* II.11.

Part VI
Methodological Defence

55. Mathematical Overdetermination as Methodological Core

The model is mathematically overdetermined, not flexibly adapted

The core methodological strength of the present framework is not the perfection of any individual geophysical assumption, but the *mathematical inevitability* of the observed spatial anomalies under multiple simultaneous constraints. The model is a **mathematically overdetermined system**: it has more boundary conditions than degrees of freedom ($F < 0$). This means that data are not 'bent' to fit; rather, different scientific disciplines validate each other.

Interdisciplinary consistency: The model combines geostatistical residuals (RMSE analyses), hydrographic topology (Lausitz river system; Mud/Mümling drainage), cartometric constraints (proportional ratios; Mercator-1569 signatures), geological boundary conditions (Doberlug Viséan anthracite; Erzgebirge ore distribution; Vogelsberg pull-apart structure), and archaeological boundary conditions (settlement hiatus; ED-E horizon predictions) into a consistent overall picture.

Refutation of the classic null model: The model shows that a classic null model — which explains the deviations through mere measurement errors or unrelated catastrophes — cannot statistically explain the cumulative, directional shifts ($t = -19.1$, $p \ll 0.001$, $df = 5$ for the extended Elster Cluster alone). The mathematical incoherence of the null model makes alternative structuring mechanisms compellingly plausible.

Methodological paradigm shift: The model shifts the focus from mere error correction of ancient maps to the investigation of real physical boundary conditions. It establishes the geodynamic hypothesis of a late antique crust reactivation (6th century) as a scientifically serious alternative.

56. The Three Principal Objections Addressed

1. **Chronological paradox vs. slow plate tectonics.** The model does not invoke classical plate tectonics to explain the 6th-century deformation. Rather, it proposes a short-term crustal detachment along the Zechstein décollement, induced by meteorite impacts. This is a specific *mechanical exception* within the overarching plate-tectonic framework. The proposed impact structures have not yet been recognised in the peer-reviewed impact-cratering literature.

2. **Preprint status.** The work is explicitly presented as a working hypothesis — an invitation to empirical falsification within stratigraphy, geophysics, archaeology,

and cartometry. Final scientific validation remains contingent on the execution of the formulated tests (T1–T34).

3. **Circular-reasoning risk.** The model strictly distinguishes between *established geographical anchors* (Rhine and Elbe mouths; Hengelo/Enschede; Bremen; Oderberg; Doberlug anthracite locality) and *highly uncertain hypotheses* (such as Anduaetium/Bamberg, uncertainty ±100 km). Methodological validation is achieved through the *cross-verification of seven independent systemic constraints* — not through individual location confirmations.

57. Conclusions: Outlook

1. **Cartometric foundation:** $\overline{\Delta\lambda} = -93.1$ km; extended cluster $t = -19.1$, $p \ll 0.001$, $df = 5$.

2. **Doberlug pressure-cooker:** Quantitatively derived; Andersonian dip prediction matches observed 60°.

3. **Universal pivot:** Same Waltershausen locus for both CW and CCW rotations; flower-structure geometry.

4. **Abnobae source pair:** Pre-deformation inter-source distance ∼26 km; verified by Mercator 1569.

5. **Vistula proportional cross-check:** ∼325 km predicted; Oder ∼300 km; decisive evidence.

6. **Impactor energy:** Multi-fragment main scenario (A') most consistent with GISP2 four horizons; $\eta_{\text{eff}} \approx 0.3$–$0.5$ at biaxially pre-loaded Coulomb threshold.

7. **Revised trigger budget:** SU 50 %/CK 35 % physically motivated by direct geometric coupling.

8. **Artesian Vistula source:** Ottendorf-Okrilla (Kiesabbaugebiet, not Braunkohle) underpinned by Albertplatz-Artesianbrunnen analogue.

9. **Integrated assessment:** ≈79 % (142/180); model internally consistent, multiply constrained, and falsifiable through T1–T34.

Priority Falsification Tests (v7-expanded)

T1–T8 (retained from v6):

SU drilling; Bouguer survey; Herzberg-area seismicity; ED-E micromorphology; CK breccia dating; décollement seismic; Main-valley/Doberlug cores; Africa-impactor

search.

T9 (v6):
Waltershausen-hinge palaeostress indicators.

T10 (v6):
Bamberg/Anduaetium archaeology.

T11 (v6):
Taunus palaeoclimate stability.

T12 (new v7):
MCZ pseudotachylyte radiometric ages: targeted SHRIMP / Ar-Ar dating of pseudotachylyte veins in major MCZ shear zones (Frankenberg-Hainichen, Nossen-Amtsberg). Prediction: detectable post-Variscan component.

T13 (new v7):
Reflection-seismic across the Rhenohercynian–Saxothuringian contact in the Werra-Saale region.

T14 (new v7):
Bramsche subsurface drilling for shock metamorphism: targeting depths >2 km.

T15 (new v7):
Mud/Mümling geomorphology: wind-gaps and palaeo-drainage indicators consistent with pre-deformation NW-flowing tributary of the proto-Rhenus.

T16 (new v7):
Horloff-Graben sediment cores: detection of 6th-century-AD mechanical disruption horizon.

T17 (new v7):
Otzberg-Zone palaeostress analysis: detection of dextral / transtensional shear component consistent with sinistral rotation of southern Abnobae.

T18 (new v7):
Vogelsberg maar-sediment radiometric / palynological: detection of possible phreatomagmatic-activation horizon ∼531 AD.

T19 (new v7):
GPS cross-profile across HTBF: detection of present-day differential motion between Taunus and Odenwald.

T20 (new v7):
Rhön xenolith chronometry: palaeomagnetic and isotopic affinity with MCZ basement confirming unified Abnobae pre-deformation block.

T21 (new v7):
Vogelsberg $^{40}Ar/^{39}Ar$ age gradient: NW (older) → SE (younger) consistent with progressive pull-apart opening.

T22 (new v7):
Ptolemaic Rhenus/Danubius source-coordinate test: predicted positions ($\lambda_P \approx 33°$, $\phi_P \approx 47°$ for Rhenus; $\lambda_P \approx 34°$, $\phi_P \approx 47°$ for Danubius).

T23 (new v7):
Palaeostress analysis Bad Hersfeld: bookshelf-scherzone centre; expected $\sigma_1 \approx 115°$–$130°$; dextral on NW-SE faults; sinistral on ENE HTBF.

T24 (new v7):
Reflection-seismic Wetzlar–Waltershausen: HTBF depth geometry and MCZ lower-crust boundary.

T25 (new v7):
AMS fabric analysis Kassel–Eisenach line: NW-SE-oriented magnetic lineation diagnostic of dextral shear.

T26 (new v7):
GPS residual velocity analysis Kassel–Eisenach–Wetzlar: expected dextral signal on Kassel–Eisenach (<0.5 mm/yr).

T27 (new v7):
Ptolemaic Mattium coordinates (Chatti capital, Bad Hersfeld area): expected residual <10 km (near-pivot location). Supplementary: Knüll basalt-schlot orientation analysis (expected ENE-WSW extensional axis consistent with bookshelf field).

T28 (new v7):
Ptolemaic displacement gradient test (Backstop → Elster-Cluster): systematic regression of $\Delta\lambda$ vs. d_{backstop} across all Elster-zone points; expected two-stage profile (Arsonion transition).

T29 (new v7):
Carrodunum archaeology Spreetal/Nochten: nachweis of Roman-period settlement at 14.06°E / 51.42°N ±15 km.

T30 (new v7):

Geoarchaeological prospection Ottendorf-Okrilla: nachweis of antique settlement near artesian spring zone.

T31 (new v7):

Prießnitz-Anzapfung OSL / ^{14}C: dating clearly $\gg$531 AD (Pleistocene), confirming spatial but not temporal reinterpretation of Vistula source.

T32 (new v7):

Isotope hydrogeology Ottendorf-Okrilla: δ^{18}O depletion (Erzgebirge high-elevation recharge); ^{14}C age >5,000 yrs; $T > 14$°C in deep boreholes.

T33 (new v7):

Historical well-documentation Klotzsche/Ottendorf: artesian-type wells before industrialisation; seasonal-constant yield.

T34 (new v7):

HTBF–Otzberg extrapolation test: GIS verification that structural extensions of HTBF and Otzberg-Zone converge within ±25 km of Waltershausen (10.4°–10.7°E / 50.7°–51.1°N).

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A. Appendix A: Complete Coordinate Gazetteer (v7-updated)

Version 7 updates to gazetteer

F2 revised from Königsbrück/Pulsnitz to Ottendorf-Okrilla (Kiesabbaugebiet; artesian spring system). New entries: S-L (Leukaristos/Finsterwalde), S-A (Arsonion/Senftenberg zone), S-C (Carrodunum/Spreetal), G9 (Abnobae Mons E, Danubius source pre-deformation), R0 (Rhenus source pre-deformation), P-Walt (Waltershausen Universal Pivot). K4 ≠ G9: K4 = stable Taunus (calibration anchor); G9 = mobile Danubius source (validation point only).

Table 31: Full gazetteer (v7). All v6 entries retained; new v7 entries highlighted). Transformation: $\hat{\lambda}_{\text{mod}} = -8.114 + 0.3989\,\lambda_P + 0.0770\,\phi_P$; $\hat{\phi}_{\text{mod}} = +35.458 - 0.0167\,\lambda_P + 0.3244\,\phi_P$. Bias correction: $\Delta\phi_{\text{bias}} = 15.2 \times \max(0, 55° - \phi_P)$ km.

#	Ptolemaic name	Identification	λ_P (°)	ϕ_P (°)	λ_M (°E)	ϕ_M (°N)	$\Delta\lambda$ (km)	$\Delta\phi$ (km)	r (km)
K1	Rhenus Fl. (central)	Hengelo/-Enschede	27.00	53.17	6.750	52.250	0.0	0.0	0.0
K2	Albis Fl. (mouth)	NW Bremen	31.00	56.25	8.583	53.183	0.0	0.0	0.0
K3	Vistula Fl. (mouth)	Oderberg	45.00	56.00	14.150	52.867	0.0	0.0	0.0
K4	**Abnobae Mons W**	**Taunus/-Großer Feldberg**	31.00	49.00	7.867	50.017	+11.2	+91.2	91.9
	(= G8, promoted to K4 southern Danubius anchor in v6;								
							$\Delta\phi_{corr} = 0$ *after bias; residual* $r_{corr} = 11.2$ *km)*		
F1	Vistula main source	Königswartha (Spree)	44.00	52.50	14.367	51.283	−61.5	+52.1	80.5
F2	**Vistula W. source (v7/Mercator)**	**Ottendorf-Okrilla**	40.17	52.67	**13.819**	**51.201**	−124.0	+64.0	142.0
		(artesian spring; Senftenberger Elbelauf; bias-corr.: 127.2)							
F3	Chalusus Fl.	Havelberg	37.00	56.00	12.067	52.817	−74.5	+21.0	77.4
F4	Suebus Fl.	Neuruppin	39.50	56.00	12.900	52.817	−63.4	+16.4	65.5
F5	Viadua Fl.	Finowfurt	42.50	56.00	13.633	52.850	−32.3	+7.1	33.1

Table 31 (continued)

#	Ptolemaic name	Identification	λ_P	ϕ_P	λ_M	ϕ_M	$\Delta\lambda$	$\Delta\phi$	r
S1	Agrippinensis*	Cologne	27.67	51.17	6.958	50.941	−6.9	+73.0	73.3
S2	Aliso*	Haltern a.S.	28.00	51.50	7.324	51.712	−20.9	−1.8	21.0
S3	Budorigum	Doberlug-Kirchhain	41.00	52.67	13.556	51.619	−87.1	+26.9	**91.2**
S4	Calisia	Calau	43.75	52.83	13.960	51.743	−38.2	+13.7	40.6
S-A	**Arsonion (v7)**	**Senftenberg zone**	43.50	52.33	**13.989**	**51.556**	**−51.5**	+17.0	**54.2**
S5	Limis Lucus	Baruth/Mark	41.00	53.50	13.499	51.993	−78.2	+9.2	**78.7**
S6	Lugidunum	Falkenberg/-Elster	39.50	52.50	13.269	51.606	−109.5	+24.5	**112.2**
S7	Stragona	Herzberg/-Elster	39.67	52.33	13.200	51.667	−101.0	+11.8	**101.7**
S-L	**Leukaristos (v7)**	**Finsterwalde**	41.50	52.67	**13.717**	**51.633**	**−87.4**	+23.7	**90.5**
S-C	**Carrodunum (v7)**	**Spreetal/-Nochten**	42.67	51.50	**14.060**	**51.420**	**−85.0**	+3.6	**85.1**
S8	Treva	Bremen	33.00	55.67	8.939	53.036	+26.6	−7.9	27.8
S9	Lirimiris	Bispingen/-Soltau	34.50	55.50	10.010	53.107	−5.9	−24.6	25.3
G1	Ascib. Mons NW	E. Magdeburg	39.00	54.00	12.283	52.167	−46.5	+17.6	49.7
G2	Ascib. Mons SE	Calauer Schweiz	44.00	52.50	13.933	51.583	−31.3	+18.7	36.3
G3	Melibocus Mons W	Harz W	33.00	52.50	9.433	52.000	−23.3	−7.2	24.4
G4	Melibocus Mons E	Harz/Eisleben	37.00	52.50	11.283	51.517	−41.2	+39.1	55.2
G5	Sudete Mons W	Kassel area	34.00	50.00	9.583	51.233	−19.8	−13.7	23.9

G5 is the Ptolemaic NW terminus of the Sudete Mons block (Thüringer Wald). Pre-deformation position: Neukirchen area (9°19′E / 50°53′N), ≈86 km due west of the Waltershausen rotation pivot (10°33′E / 50°53′N) — same latitude, consistent with the E–W pre-rotation block geometry. After 35° dextral rotation about this central block hinge, G5 swept ≈52 km northward to its modern cartometric position (Kassel

Table 31 (continued)

#	Ptolemaic name	Identification	λ_P	ϕ_P	λ_M	ϕ_M	$\Delta\lambda$	$\Delta\phi$	r
	area). Rotation-corrected residual ≈11 km (within identification uncertainty). G5 lies on the outer SU deformation ring boundary (≈106 km from Stolberg) and within the biaxial Bramsche–Geiseltal stress corridor — the maximally loaded mobile NW flank.								
G6	Sudete Mons E	Thur. Slate Mts.	40.00	50.00	11.533	50.367	+11.2	+71.6	72.5
	G6 is the Ptolemaic SE terminus of the Sudete Mons block (Thüringer Schiefergebirge/ Lobenstein area). Pre-deformation position: ≈ 11°49′E / 50°49′N, ≈90 km nearly due east of the rotation pivot at Waltershausen (10°33′E / 50°53′N). After 35° dextral rotation about this central block hinge, G6 swept ≈54 km southward to its modern position, approaching the Danubius Fl. (Main). Rotation-corrected residual ≈0.1 km (essentially exact): the rotation model predicts G6's modern position to within cartometric noise. The eastern Sudete Mons thus approached the Danubius reference line from ≈110- -120 km (pre-rotation) to ≈30–40 km (post-rotation).								
G7	Sarmate Mons N	Lusatian Highlands	43.50	50.50	14.467	51.133	−93.9	−2.2	94.0
	T-G + biaxial NE lateral extrusion; pre-deformation position 5.2 km from SU–CK axis; azimuth 53° vs. expected 44.4°; ΔN = +70.6 km bias-corrected.								
G8/K4	Abnobae Mons W	Taunus (= K4)	31.00	49.00	7.867	50.017	+11.2	+91.2	91.9
G9	**Abnobae Mons E**	**Danubius src. pre-def.**	—	—	**≈8.96**	**≈50.07**	—	—	—
	(post-def.: Marktheidenfeld/Wertheim; d ≈ 55 km)								
R0	**Rhenus src. pre-def.**	**NW-Odenwald**	—	—	**≈8.60**	**≈50.06**	—	—	—
	(post-def.: Amorbach; d ≈ 63 km)								
P-W	**Walters-hausen Pivot**	**NW Thür. Wald**	—	—	**10.542**	**50.882**	—	—	—
	(universal pivot for Sudete CW and Abnobae CCW)								

*Gallia Belgica; evaluated separately.

Key v7 changes: F2 revised after Mercator map interpretation to Ottendorf-Okrilla (gravel-mining area; Senftenberger Elbelauf; artesian Cenomanian aquifer); three new EC points (S-L, S-A [décollement tip], S-C); three new geographic reference entries (G9, R0, P-Walt).

A.1 Saale-Unstrut Crater Geometry

Table 32: Saale-Unstrut Fragment Impact: geometric parameters (working hypothesis; not confirmed in peer-reviewed literature).

Element	Identification	λ (°E)	ϕ (°N)	d from Stolberg (km)	Notes
Inner crater centre	Schnellroda/ Geiseltal	11.73	51.33	≈57	transient cavity
Outer-ring centre	Stolberg	11.00	51.57	0	ring-fit centre
Outer deformation diameter	—	—	—	—	180–200 km
Southern outer rim					
Oberhof	TW high ridge	10.73	50.70	≈99	**excellent rim fit**
Ilmenau	TW NE margin	10.91	50.68	≈99	**excellent rim fit**
Eisenach (TW NW)	—	10.32	50.98	≈81	inner edge
Down-range lobe and backstop					
Herzberg/Elster	—	13.23	51.68	≈154	down-range overthrust
Senftenberg	Lausitz backstop	13.97	51.54	≈208	arrest of Elster glide
Virtual pivot and outer reference					
Waltershausen pivot (v6)	Sudete terminus	10.54	50.88	≈ 83	**on southern outer rim** — natural rotation hinge of the Thüringer Wald block
Bramsche pluton	passive endpoint	8.00	52.42	≈227	NNW structural limit

A.2 Tentative Anduaetium Identification (NEW in v6)

Table 33: Anduaetium / Bamberg hypothesis: tentative secondary Danubius anchor with large uncertainty. *Hypothetical; not a confirmed identification.*

Ptolemaic name	λ_P	ϕ_P	Notes
Anduaetium /	40°30′	47°40′	Documented in Book II, Ch. 10; in the southern Barbaricum / Danubius zone
Tentative modern identification:			
Bamberg area	10.89°E	49.89°N	Bamberg lies on the Regnitz river, ≈ 3 km upstream of the Regnitz–Main confluence; thus near but not directly on the Main
Model prediction	11.71°E	50.25°N	Affine transformation output
Uncorrected residual	≈ +59 km W; +40 km N	$r \approx$ 71 km	Before bias correction
Bias correction	−111.4 km	—	$15.2 \times (55 - 47.67) = 111.4$ km
Corrected $\Delta\phi$	−71.7 km (S)	—	Bias-corrected ϕ-residual: the affine model predicts 71.7 km *north* of Bamberg (after coastline-shift correction). Combined with the $\Delta\lambda = +59$ km (affine prediction east of Bamberg), the total bias-corrected displacement vector is ≈95 km towards NNE — consistent with dual CK-driven eastward and northward forcing in the biaxial stress field. Note: interpretation is highly uncertain given the ±100 km identification uncertainty.
Position uncertainty	± ≈ 100 km	—	Due to massive biaxial overprinting in this region

The ≈ 72 km northward discrepancy after bias correction is consistent with a northward displacement of Anduaetium from its original position (south of Bamberg) toward the Český Kráter in the 6th-century deformation episode. This interpretation is tentative and subject to a factor ±100 km uncertainty. The Bamberg / Regnitz–Main area remains a candidate location for the original settlement, with the Regnitz functioning as a tributary of the Main / ancient Danubius rather than the main river channel itself.

A.3 CDF and Elbe-Lineament Reference Points

Table 34: Reference nodes of the CDF/TTZ and Elbe Lineament.

Node / Segment	λ (°E)	ϕ (°N)	Notes
CDF / Trans-European Suture Zone			
CDF-W (central North Sea)	4.5	54.5	MONA LISA 3
CDF-Mecklenburg-Vorpommern	11.0	54.2	NE-Germany main trace
CDF-Rügen-West (Wiek Fault)	13.3	54.5	
TTZ-transition (Pomerania)	16.5	54.0	link to Polish Tornquist
Elbe Lineament			
SW endpoint (Dresden-Meißen)	13.4	51.1	Saxothuringian / N German Basin boundary
Central node (Halle-Magdeburg)	12.0	51.9	intersection with Asciburgius hinge
NW endpoint (Bremerhaven)	8.5	53.5	North Sea continuation

A.4 Mineral Deposit Coordinates (from KML, unchanged from v4)

Table 35: Coordinates of mineral deposits referenced in the text and plotted in the geodynamic map (from KML layer `possible Impact Structures`, v. 20, doi: 10.5281/zenodo.20289766, 19 May 2026). d_{CK} = great-circle distance to Český Kráter centre; d_{SU} = distance to Saale-Unstrut inner crater centre (Schnellroda). All coordinates WGS84.

Deposit / Site	λ (°E)	ϕ (°N)	d_{CK} (km)	d_{SU} (km)	Type / Remarks
Hard coal and anthracite					
Lugau-Oelsnitz	12.729	50.725	212	100	Hard coal; inter-impact corridor
Freital / Döhlen Basin	13.657	50.989	240	155	Hard coal
Doberlug-Kirchhain	13.554	51.616	282	130	**Anthracite**; Viséan protolith + SU down-range overprint (v5) = Budorigum
Barsinghausen	9.470	52.299	490	88	Hard coal; near Bramsche axis
Ibbenbüren	7.740	52.286	585	126	Hard coal
Hilter a.T.W.	8.125	52.169	540	106	Wealden coal
Bielefeld Revier	8.440	52.044	510	98	Hard coal
Oschatz	13.105	51.300	255	97	Hard coal occurrence
Kaolin					

Table 35 (continued)

Deposit / Site	λ (°E)	ϕ (°N)	d_{CK} (km)	d_{SU} (km)	Type / Remarks
Caminau (Upper Lusatia)	14.343	51.337	265	169	**Within farthest CK ring**; Zone B
Kemmlitz	12.993	51.227	271	101	**Marginal farthest ring**; Permian rhyolite
Meissen-N (Ockrilla)	13.501	51.211	240	137	Zone B
Meissen-S (Löthain)	13.400	51.144	239	133	Zone B
Karlovy Vary	12.879	50.230	184	86	Zone B; within outer crater rim
Hirschau / Schnaittenbach	11.961	49.543	218	186	Zone B
Tirschenreuth / Rappauf	12.327	49.882	184	155	Zone B
Kupferschiefer (copper shale)					
Sangerhausen (Thomas-M.-Schacht)	11.292	51.483	320	44	Zechstein, Permian
Mansfeld / Eisleben	11.589	51.602	323	36	Largest European Cu-Ag deposit
Mosbach	10.358	50.935	400	67	Kupferschiefer occurrence
Ilfeld (Lange Wand)	10.787	51.567	345	34	Kupferschiefer